Robots in Nursing:

Feared Rhetoric or Future Reality?

How might robots contribute to hospital nursing in the future? A qualitative study of the perspectives of roboticists and nurses.

OXFORD BROOKES UNIVERSITY

Thesis submitted in fulfilment of requirements for the award of

Professional Doctorate in Nursing. Oxford Brookes University

September 2023

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Thank you to:

- **Flo** who gave me the topic and challenged me to do something for nursing and something for the future – thank you for starting me on the journey;

- **Winston Churchill Memorial Foundation** for sponsoring the Travel Fellowship which shaped this study;

- Each **participant**, your gift of time and wisdom is priceless – thank you;

- My **supervisors** and three **Directors of Studies** – thank you for your encouragement and enthusiasm (especially when mine was waning). Peter – thank you for your subject matter expertise and wisdom, Kathleen – your focus on nursing and eye for detail kept me on track. A particular thank you to Helen Walthall, programme founder, who supervised my early planning and assisted with participant access and to Helen Aveyard whose constant enthusiasm got me to the finish line;

- My **family and friends**, especially my husband who gave up a number of his own dreams to support mine and my precious sons whose own university studies provided the accountability and encouragement to keep going;

- The **seven phronetic sisters** (my doctoral colleagues) who are a source of inspiration and delight – you have made these last six years wonderful;

- The **patients** I did not get to include, you were in my thoughts throughout- the reason for undertaking this study to help nursing to serve you in the future.

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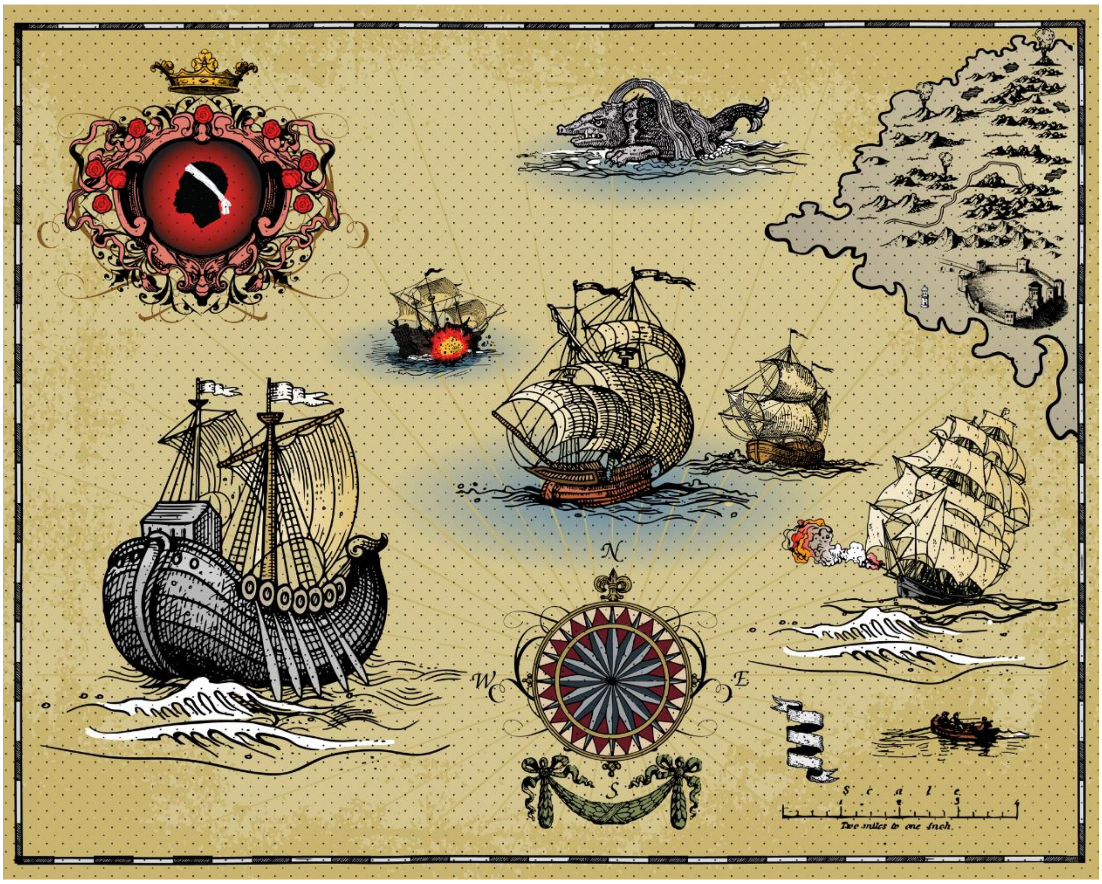
Glossary of Abbreviations

Abbreviation and Context		Full Title	Explanation
Organisations	AIST	Advanced Industrial Science and Technology	National Institute of Advanced Industrial Science and Technology (Japanese Research Facility)
	ICN	International Council of Nurses	Federation of over 130 national nurses associations representing over 28 million nurses worldwide
	NMC	Nursing and Midwifery Council	Regulatory registration body for UK nurses and midwives, responsible for setting standards for nursing and midwifery education
	NHS	National Health Service	Public Health Service body for the UK
	ONS	Office of National Statistics	UK Office of UK Statistics Authority
	OECD	Organisation for Economic Co-operation and Development	Intergovernmental organisation with 38 member countries
	RCN	Royal College of Nursing	Trade union and Professional Body for Nurses in UK
Searching Databases	CINAHL	Cumulative Index of Nursing and Allied Health Literature.	Database of literature from US, UK and other countries
	BND	British Nursing Database	Full Text nursing and midwifery database
	PUB-MED		Search engine accessing primarily the Medline database
	IEEE	Institute of Electrical and Electronics Engineers	Membership organisation providing access to electrical and computational engineering databases including robotics (includes conference proceedings and grey literature)
	EBSCO Open Dissertations		An interface or search engine accessing multiple different databases, including open access dissertations and Theses
	EThOS		Theses Digitalisation database of 600,000 theses (managed by the British Library)
	NDLTD	Networked Digital Library of Theses and Dissertations	International library of over 1M Theses and Dissertations
Presentation of Results	R	Roboticist	Refers to Phase 1 participants (followed by a number referring to roboticist interviewee 1-5)
	RN	Registered Nurse	RN followed by a number, refers to the number of the focus group /or interview 1-9 and number of the participant within that focus group 1-6)
	NL	Nurse Leaders	Refers to participants of Phase 3. NL followed by a number indicates number of focus group 1-4 and participant number within focus group 1-5
Technology Acceptance Theories	TAM	Technology Acceptance Model	Model developed to predict acceptance of computer technology, used in a number of studies (Davis *et al.*, 1989)
	UTAUT	Unified Theory of Acceptance and Use of Technology	Later theory developed to predict acceptance and use of technology (Venkatash *et al.*, 2003)

Glossary of Abbreviations (cont)			
Abbreviation and Context		**Full Title**	**Explanation**
Nursing Theories	FOC	Fundamentals of Care	A mid-range theory for nursing developed in 2007 by Feo et al (2017)
	TRETON	Transactive Relationship of Nursing Theory	Tanioka's (2017), Midrange theory of Nursing developed within the technology context
	MIRTH	Model of Intermediary Role of Nurses in Transactive Relationships	Osaka's (2020) Model to support introduction of robots to nursing.
Robot Type	SAR	Socially Assistive Robot	Robot that provides social support by responding to human command or touch



“. . . here be dragons. . . .”

([Latin](): *hic sunt dracones*) means dangerous or unexplored territories, in imitation of a medieval practice of putting illustrations of [dragons](), [sea monsters]() and other mythological creatures on uncharted areas of maps where potential dangers were thought to exist. (Waters 2013)

Abstract

Introduction.

The challenge of the global nursing shortage coupled with a rising healthcare demand prompts consideration of technology as a potential solution. Technology in the form of robots is being developed for healthcare applications but the potential role in nursing has not been researched in the UK.

Methods

A three-phased qualitative study was undertaken: interviews with 5 robotic developers (Phase 1); nine focus groups /interviews with 25 hospital Registered Nurses (RN) in Phase 2, and 12 nurse leaders in four focus groups (Phase 3).

Data was analysed using framework analysis for Phase 1 and reflexive thematic analysis for Phase 2 and 3 data based on the Fundamentals of Care framework.

Results

Roboticist interviews confirmed that a taxonomy of potential robotic automation was a useful tool for discussing the role of robots. In Phase 2, RNs described activities that robots might undertake and commented on those which they should not. RNs more readily agreed that robots could assist with physical activities than relational activities. Six potential roles that robots might undertake in future nursing practice were identified from the data and which have been labelled as advanced machine, social companion, responsive runner, helpful co-worker, proxy nurse bot, and feared substitute. Three cross-cutting themes were identified:

- a fear of the future;
- a negotiated reality and
- a positive opportunity.

In phase 3, nurse leaders considered the RN results and four themes were identified from their discussions:

- First impressions of robot in nursing;
- The essence of nursing;
- We must do something and
- Reframing the future.

Conclusions

Robots will be a future reality in nursing, playing an assistive role. Nursing must become technically proficient and engage with the development and testing of robots. Nurse leaders must lead policy development and reframe the narrative from substitution to assistance. A number of navigational tools have been developed including a taxonomy of nursing automation and the six robotic roles which may be useful to inform future debate in nursing.

Chapter 1: Introduction to the Study

1.1. Introduction to the Chapter

Imagine being admitted to a hospital in the future – might you expect to be cared for by humans assisted by other humans? Or perhaps you expect that robots (machines that can sense and move, equipped with artificial intelligence), might play a role? The global shortage of healthcare professionals accompanied by increasing healthcare need and increasing technological advances leads some to suggest that robots might be the answer. With global nursing shortages expected to escalate, the question is whether this scenario is false rhetoric or could be a future reality. This study answers that question by exploring the future role of robots in the delivery of nursing care from a number of perspectives; those who develop robots (the roboticists); the likely operators of robots, i.e. the front-line nurses and thought leaders and nursing policy influencers including chief nurses. This research aims to be future-forming in nature: that is by researching and discussing the topic of robots, nurses actively start to shape the contours of the nursing future (Gergen, 2015).

1.2. Demographic Context

Future healthcare need is expected to rise due to population growth, population ageing, and the increased burden of chronic disease (Buckinx *et al.*, 2015; Charlesworth *et al.*, 2018). In England, the population of over 65 years old is expected to reach almost 15 million by 2040 (an increase of 49% since 2017 according to Age UK, 2019). As people grow older and live longer the likelihood of health and social care need also rises, with the number of people aged over 85 years old expected to almost double to 3.1 million by 2045 (Office for National Statistics, 2021).

This is expected to lead to increased demand for hospital services as ageing is associated with increasing frailty and in turn, is linked to a greater risk of hospitalisation, long hospital stays, and unplanned re-admissions (Street *et al*., 2021).

The increasing complexity of healthcare needs may also see an increasing demand for health services (Health Foundation 2021). Furthermore, hospital activity is predicted to rise over the next 10 years with some sources estimating that elective waiting lists will rise to more than 13 million by 2030 (Bhangu, 2022) and this is likely to drive a corresponding rise in demand for nurses.

1.3. Global shortfalls in nursing

At the same time as healthcare need is rising, there is a global nursing shortage. This was a well-documented issue before the pandemic as revealed by the State of the World's Nursing Report in 2020 by the World Health Organization (WHO). In 2020 the total global nursing workforce was stated at 27.9 million with an estimated global shortfall of 5.9 million nurses (WHO, 2020).

Nursing supply is expected to be severely affected over the next decade and the global nursing shortage to rise to 10.6 million nurses by 2030. This could be as high as 13 million if retirement and leaving rates exceed 20% according to the International Council of Nurses (ICN, 2022). Even with mitigation (such as delaying retirement or improving retention), the ICN estimates global nursing shortages will exceed 10.88 million by 2030. These shortages may escalate the rate of leavers as fewer nurses care for too many patients and the pressure on the existing workforce increases, leading to the global emergency described by the ICN Chief Executive (Baines, 2023).

Global figures are relevant to UK nursing for two reasons, firstly the UK is likely to rely on overseas recruitment as one mechanism for maintaining its nursing workforce numbers. Secondly, the UK has a relatively small number, (30 per 100,000 population) of nurses graduating per year (OECD 2021) although the recent NHS Long Term Workforce Plan (2023) aims to double this by 2031/32. This 30 per 100,000 population compares poorly to other developed countries such as Australia (at more than 100 per 100,000), Norway (76) and Finland (82) (OECD 2021).

The UK nursing situation looks bleak, evidenced by the first nurses strike in over 100 years in December 2022 and early 2023. In 2021, 57%, of nurses responding to a Royal College of Nursing (RCN) online survey reported they were considering or planning to leave. Their reasons were: feeling under too much pressure (61%), feeling exhausted (60%), and low staffing levels (59%). A worrying 62% reported that they are too busy to provide the level of care they would like to (RCN, 2021). It is predicted that by 2037 NHS workforce shortfalls will reach between 260,000 and 360,000 staff (NHS England, 2023). Despite the inclusion of an additional 50,000 more nurses by 2023/4 nurse shortages are still expected to reach 40,000 in England as early as 2023-24 due to changes in demand and expected leavers (Health Foundation, 2022).

1.4. Technological Advances

The issue of a disparity between healthcare demand and the available healthcare workforce has led to technology being offered as a possible solution. The development of technology presents both an opportunity and a potential solution (Buchan, Catton & Shaeffer, 2022). However, countries like Japan, Korea, and Italy, with a super-aged population of 20% over 65 years old by 2030 (Hyun, Kang, & Lee, 2016), view robotics development as more of a necessity. It comes as no surprise that Japan, Korea, and the US (which is also projected to become super-aged by

2030) are leading the way in technology development to address the needs of the older population. In Korea, the declining proportion of younger people able to care for the ageing population is also a concern (Park *et al.,* 2019; Gibelli *et al.,* 2021).

In the UK, the rate of ageing may be slower compared to other countries, but the population is still expected to become super-aged by the year 2025. Therefore, there is a genuine concern about how nursing shortages may affect the quality of healthcare provided when needed (Triggle, 2022). Staff shortages are evident in hospitals, homes and clinics, and nursing leaders must think strategically and plan how nursing can respond to these challenges.

At the same time, technological advances are progressing at pace, such that these current decades are described as the digital age (Rouse, 2017). The pandemic also saw a rise in technology use and adoption (Sorrentino, 2021) and there is now a window of opportunity to influence the future reality. To date, whilst there is investment in digital nursing leadership and building digital capability for nurses, there is not much evidence of discussion of how robots might play a role in the future. However, autonomous robots are a developing field of technological development and one which is expected to see an increase over the next decades, due in part to countries such as Japan and the US funding national programmes of robot development in health (Headquarters for Japan's Economic Revitalization, 2015). According to the International Federation of Robotics (2021), the nursing and medical aspects of the Japanese New Robot Strategy were valued at $997.3 Million. Since 2015, the Japanese government has provided subsidies for the purchase of robots by healthcare facilities. The country has invested heavily in projects to enhance robotic nurse assistants to detect and predict health-related changes among individuals.

Inevitably such programmes will be focused on the development of reliable technologies as an answer to the principal issues facing older people: physical decline, cognitive decline, health management, and psychosocial issues (Robinson, Macdonald and Broadbent 2014). Given these are the same issues that healthcare provision is grappling with, it is likely that robotic technologies will increasingly be suggested as a part of the future and suggestions made about the extent to which robots may provide a viable substitute for scarce nursing resources. Moreover, without a strong voice, nursing is in danger of having its future determined by others (policies and politicians) according to Salvage and White (2019). Strategic nursing leadership (nurses in executive and regional /national leadership roles) must have a clear voice on the unique and pivotal contribution that nursing makes to clinical care. Without this, there is a very real risk that technologies will be developed for nursing without sufficient nursing engagement which may not be fit for purpose or may bring about some unintended consequences. History is littered with technology where usage has been problematic such as the Danish robotic bathtub (Beedholm, Frederiksen and Lomborg, 2016), and the hair-washing robot developed by Hirose *et al*., (2012) both of which were developed to address a nursing need but failed to address the complexity of care.

1.5. Definition of a Robot

The origin of the word robot has been attributed to the cubist painter and writer Josef Capek who suggested the name to his brother Karel Capek, a Czech novelist and playwright who was looking for a name for artificial workers for his next play. The word Roboti is a derivation of the Czech noun “robota”, meaning “forced labour” which translated into English is ‘Robot’. The word first appeared in the play R.U.R (Rossum’s Universal Robots) published in 1920. (Robots Academy, 2022).

Interestingly the play tells the story of a company that learns how to mass-produce workers who *"lack nothing but a soul".* The robots undertake all the tasks that humans don't want to do and, the company becomes very successful. In the last act, the robots themselves revolt against the humans and start to kill humans until they realise that they need humans love and compassion in order to survive (Science Friday, 2011). Whilst a play, there are some nuances of this messaging that have been reinforced through science fiction films such as Terminator (Cameron, 1984) and which still affects attitudes today.

Shortly after its creation the Robot Institute of America issued a definition of a robot in 1979:

> *"A robot is a reprogrammable, multifunctional manipulator designed to move material, parts, tools, or specialized devices, through variable programmed motions for the performance of a variety of tasks."*

The international standard ISO 8373:2021 defined robots as

> *"a programmed actuated mechanism with a degree of autonomy to perform locomotion, manipulation, or positioning".*

These definitions are amongst the most used, albeit somewhat technical. In the literature review (Chapter 3) only six of the papers included a definition of robot including Chang *et al.,* (2021) who defined robots as

> *"software-programmed machines that can sense or interact with the environment to flexibly implement various tasks".*

This simpler, shorter definition retains the same key elements of a robot that is:

- a machine;
- programmable;

- interacts with the environment;
- implements various tasks.

This latter definition will be used as a point of reference for this study.

1.6. Definitions of Artificial Intelligence

This study explores the role of robots in nursing. Since nursing as a practice comprises both mental and physical capability, the question arises about the physical and mental capabilities of the robot so that decisions may be made about what robots can do. This research assumes that robots will be equipped with Artificial Intelligence (AI) as standard, concurring with Beer *et al.,* (2014). AI refers to the computer's ability to imitate human decision-making. Whilst a computer can only execute instructions and programs, AI uses data processing to identify solutions. This can be done through algorithmic machine learning, which searches for patterns in organised data to make predictions or run simple applications, or deep learning, which can handle unstructured data and operate autonomously through self-learning. In simpler terms, Khanam, Tanweer and Khalid (2021) define AI as the intelligence exhibited by machines, machine learning as a means of achieving AI, and deep learning as a technique for implementing machine learning.

This study is situated in the context of fast-moving developments in Artificial Intelligence, defined as *'the capacity of computers to exhibit or simulate intelligent behaviour'* (Oxford English Dictionary, 2023). Recently concerns about this escalating capability, pace and lack of regulation have been raised by individuals such as Geoffrey Hinton, Elon Musk and Yuval Harari (BBC, 2023a; 2023b; Harari, 2023). According to Khanam, Tanweer and Khalid (2021), machines powered by AI now surpass human capability in multi-tasking, rational decision-making, accurate computation, information retrieval, speed, and capacity. However, they still lag behind human intelligence in numerous aspects, such as logical reasoning, natural and linguistic language processing, creativity, artistic ability, deliberation, and emotional intelligence. The inclusion of multi-tasking here is a contentious one, as Google confirmed in 2017 that AI was capable of juggling 7 things at once, which would appear to be significantly less than a human brain given the functions of movement and physiological regulation (Reynolds, 2017). Indeed Khanan, Tanweer and Khalid (2021) liken the artificial intelligence of 2020 to the equivalent of around 1% of the human brain while predicting a 50% likelihood that artificial intelligence will exceed human capability in **all** areas in the next 45 years. Therefore, it is reasonable to assume that artificial intelligence will be intelligent enough to assist some nursing functions in the next 10-15 years (the timeframe for this study).

Robotic Process Automation (RPA) is one form of artificial intelligence based on software robotic that might assist nurses in the future. However, including RPA would have widened the study to consider all digital technology. Therefore, although the name suggests a robot, RPA was excluded as it did not meet the definition of movement discussed in section 1.5. It is acknowledged however that future robots may well include elements of RPA in the future.

1.7. Context of this research: Strategic Nursing Leadership

Strategic Nursing leadership is often encapsulated in nurse executive job descriptions and alludes to a long-term perspective and seniority to affect the future. Strategic leadership capability is wider than simply the leadership competencies and attributes required to step into the strategic space (White, 2012), and White (2019) proposes a focus on impact. It is this area of strategic leadership that underpinned the need for this study. The strategic context was one of exponential technology development, challenging workforce shortages and a historically sensationalist media that declared that robots will take nursing jobs (Peck, 1992) or be more effective than human nurses (Naish, 2009). This study aimed to provide evidence-based insight from robot developers (roboticists), registered nurses providing hands-on care in UK hospitals, and strategic nurse leaders to ensure that distinctive perspectives can be included in future policy-making and decision-making (Salvage and White, 2019).

It is therefore crucial that nursing leadership considers this topic. Nursing as a profession needs to have a voice on the role that robots might play in the future. This must be a reasoned and articulate voice based on evidence and research about what is practical and appropriate for patients, nurses, and the sustainability of the nursing profession. The reasons for this are threefold:

1. To enable nursing and nurses to respond to questions about substitution and assistance.
2. To inform workforce plans and progress workforce development for nursing.
3. To position nursing to harness the potential offered by robotics for the benefit of the people that nurses service i.e. patients, clients and those close to them.

1.8. Research Question and Aims of the Study

The aims were future-focused, primarily because of the lead time of at least 3 years to recruit and train registered nurses, longer if curriculum changes are needed. Secondly, in order to influence strategically it is important that any recommendations do not (because of technological developments), become out of date before they are published. Therefore, a future time period of 10-15 years was proposed for this research with the research question as follows:

"What is the future role of robots in hospital nursing in the next 10-15 years? A qualitative study of roboticists and nurses' perspectives"

The following objectives were identified for the study:

- to explore robot developer's views of the future likely capability of robots in the next 10-15 years in nursing.
- To explore and analyse nurses' perspectives on what might be acceptable and appropriate roles and activities, for robots in hospital nursing.
- To identify the factors that might support or be a barrier to robot use in the future delivery of nursing care.
- To propose how robots might contribute to the delivery of hospital nursing and make recommendations for the next steps.

1.9. Overview of Thesis

This thesis is presented in 10 chapters and an overview of each chapter is given below:

Chapter 1. This Chapter / Introductory Chapter.

This chapter explored the future workforce challenge in nursing and introduced the notion that robots may play a part in the future delivery of nursing care. The chapter included a definition of robots and referred to the exponential development in Artificial Intelligence. The context of strategic leadership as the social context for the study and the need for future forming research to contribute to a necessary debate were outlined. This chapter concluded with a presentation of the aims of the study and the research question.

Chapter 2. Background Chapter.

This chapter considers the background to the study starting with a description of insights from a Winston Churchill travel fellowship followed by exploring the conceptual definitions of nursing. The chapter then considers perspectives from the wider literature on robots in health and social care because robots used for one purpose within one context, may in the future be considered in a different context. This chapter includes definitions of nursing, introduces the Fundamentals of Care framework, makes mention of nursing theory related to technology use and considers existing theories of technology adoption.

Chapter 3. Literature Review.

This chapter considers published research related to the role of robots in nursing undertaken in a hospital setting and comprises an integrative review of fifteen studies. The integrative review demonstrates that whilst a number of scoping reviews have been carried out, the research examining the future role of robots in nursing within a hospital environment is limited and none have been conducted in adult care in the UK.

Chapter 4. Methodology Chapter.

This chapter describes the research question and aims and explores the theoretical foundations and research paradigm that underpin the study. The choice of methodological approach is discussed concluding that a social constructionist approach within the social constructivist paradigm best fits the exploration of this topic.

Chapter 5. Methods Chapter.

This chapter describes the three-phase design and highlights the iterative nature of the study: Phase One interview findings from robotic developers being presented to Phase Two Participants (registered nurses in online focus groups) with Phase Two findings being presented to chief nurses and thought leaders. The study's recruitment is described with details of participant numbers and recruitment approaches. The chapter includes reflexivity and concludes that despite elongated problematic recruitment, the face-to-face method was the most effective method for front-line nurses and enabled first-hand observation of reactions to the topic.

Chapter 6. The Robotocist perspective.

This chapter presents the framework analysis of five interviews with Robot developers or roboticists. Their insights confirm the components of a robot as comprising sensors, a motor and a computer and will generally be equipped with AI and concludes that a robot is unlikely to be able to substitute for a nurse in the next 50 years is elucidated with the recommendation that robots might assist nurses in the future. The revision of the developed taxonomy is presented.

Chapter 7. RN perspectives.

This chapter presents the findings from the registered nurse focus groups and firstly focuses first on the range of perspectives of the activities that a robot could or should undertake using the Fundamentals of Care framework. Secondly, the chapter presents six roles identified in the data that describe the roles that robots might take in the future delivery of nursing. Thirdly three undercutting themes are presented which may explain the underpinning rationale for the registered nurses' perspectives, these are:

- a fear of what the nursing future might hold;
- a negotiated reality of a future shared with robots and
- a positive opportunity.

Chapter 8. Nurse Leaders' perspectives.

This chapter presents the analysis of insights from senior leaders in nursing. Four inter-related themes are presented:

- First impressions of 'Robots in Nursing;
- The essence of nursing;
- We must do something'- the need for debate and
- Reframing the future as 'robots can assist'.

Chapter 9. Discussion.

This chapter considers the principal findings in the context of the literature, including theories of technology acceptance and technology in nursing. An overview of what this study adds, with a summary of the new knowledge is presented in table form at the beginning of the chapter. The findings inform conclusions that robots will not replace nurses in the next 10-15 years but are likely to be introduced to hospitals to assist nurses. The chapter concludes that nurses need to actively engage in robotic development and design and nurse leaders need to lead policy discussion and debate to shape the future.

Chapter 10. Conclusion and Recommendations.

This chapter provides a summary of the seventeen conclusions from the study before considering the strengths and limitations of the study. Recommendations for further research, for education, practice and for strategic nursing leadership are presented.

Chapter 2: Background to the Study.

2.1. Background Chapter Overview

The global nursing workforce challenge is immense, and technology, specifically robotic technology, is being considered as one of the solutions. Having defined what a robot is, this chapter presents my initial insights from a travel fellowship in 2019 which informed my thinking regarding the research topic. The chapter considers conceptual definitions of nursing before exploring the current state of robots in health and social care and then four mid-range theories of nursing which are relevant to this study. The chapter includes consideration of the wider context of social robotic development as some social robots are being considered in hospital contexts, (Sarabia *et al.*, 2018; Hung *et al.*, 2021).

Following consideration of how robots are currently used, this chapter considers what is known about the capability, reliability and acceptance of robots.

2.2. Travel Fellowship

Having decided on the topic for this study I was fortunate to be awarded a Winston Churchill Travel Fellowship to look at international examples. I travelled to China, Japan, Australia and New Zealand to explore robot development in health and social care and to discuss how this technology might be situated within nursing. The individuals who contributed to the insights are listed in ***Appendix*** 1 and the insights are summarised in the table below and have informed my thinking on the topic.

Table 2.1: Insights and 'take-home messages from Winston Churchill Travel Fellowship

Table: Insights and take home messages from Winston Churchill Travel Fellowship		
	Insight	**Key take away messages**
1	How machines learn	Machines learn by watching videos and anticipating human behaviour
2	Robots cannot replace nurses	Robots may assist nurses in the future 10-15 years but cannot replace them.
3	Robots can anticipate human action	Human Robot Collaboration is a developing science within Robotic development and may expand into healthcare
4	Physical constraints limit robot capability	Robotic strength, battery life and stability may develop later than AI decision making capability
5	Clinicians learn from aberration	Artificial intelligence regarding aberration in imaging may assist clinicians
6	Humans are the comparators for safety and accuracy.	We expect higher levels of safety and accuracy from robots than humans
7	Handover is greatest area of risk	The point of handover between Robot and Human is the most risky
8	Levels of Automation	The automotive industry levels of automation could be adapted for nursing
9	Definition of a robot	Robots have three components: a motor, sensor and computer
10	Robotic Development must be resilient	Robotic Development needs to take account of simplicity, application to basic needs, autonomy and robustness of design
11	Flexibility and creativity capabilities influence technology adoption	Capabilities of Flexibility and Creativity are key for robotic adoption
12	Sensors are available now and could make a real difference	Sensors are the most likely healthcare technology to make the biggest difference in next 5 years
13	Human to Robot interaction can increase human to human interaction	Using robots increases the human to human interaction (perhaps due to novelty) and allows health professionals to focus on interaction
14	Technology development must be done with clinicians	Developing robots works best as a team approach with clinicians
15	The role of Avatars	Avatars don't filter so they assist the delivery of comprehensive patient education
16	Future focus on a type of technology and impact	Be clear on my research question – Focus on a type of technology not a commentary on technology. Autonomous robots might have the biggest impact on autonomous nursing
17	Fundamentals of Care	The integrated nature of care may be the non-substitutable essence of human nursing
18	Role of relationship and risk in care	Nurses must oversee clinical risk and therapeutic relationship in robot deployment but be careful robot capability in interaction is developing exponentially so may not be unique
19	Robot design of assists interaction	The appearance and movement of a robot in human or animal form increases trust in the robot
20	Student preparation for the future	Problem solving is an essential nursing skill for the future
21	The value of the Churchill Fellowship	Winston Churchill offers not only a travel fellowship but lasting friendships across the world

The key insights of particular relevance to this study included robot safety, robot development and the impact of using robots in terms of improved human-to-human interaction and are discussed below.

At the IEEE (Institute of Electrical and Electronics Engineers) robotics conference in Hong Kong, speakers debated whether robots should have the same level of accuracy and safety as humans. High-profile accidents involving self-driving vehicles were discussed and experts emphasised that human intervention becomes necessary when robots are not equipped to handle unexpected situations. The point of transfer of control from robot to human poses the greatest risk, as the driver may be unprepared to take back control in cases of imminent failure or difficulty. The robot-human interface is therefore safety-critical and is still a focus of technological development.

In individual discussions, several speakers agreed that robots are unlikely to replace nurses in the next 15 years, predominantly due to limitations in physical capabilities and hardware development. Experts highlighted problems with the instability of walking robots and their inability to carry heavy loads such as patients, in addition to battery life and reliability issues which have yet to be solved.

At this same conference, one presentation adapted the self-driving car automation levels to medical practice, illustrating different levels of autonomy. I recognised that this framework could be adapted to categorise nursing robots and perhaps explain different levels of robot autonomy.

In Japan, the National Institute of Advanced Industrial Science and Technology (AIST) run a programme of testing new technology to ensure it is safe and reliable. Devices with simple robotics were considered less likely to malfunction and most were designed to address mobility and toileting issues. I observed such devices being tested in practice in the long-term care facility of Zenkoukai Sante Fe, including a storeroom of discarded prototypes deemed too complex or impractical for patient use. However, technology using sensors and AI algorithms was in use and albeit not robots, sensors were predicted to have the most significant impact on care in the next five years. The significance for this study is that robots may be routinely equipped with such sensor/AI technology in the future.

During my visit to Tonsley Campus (at Flinders University in Adelaide), I was challenged to consider which technologies would have the greatest impact on the future and concluded that autonomous robots have the biggest potential to impact the future of nursing practice. These discussions were pivotal in refining my research question.

The positive impact of robot usage on human-to-human interaction was observed with three different robots, firstly in Tokyo, where 'Pepper' robot was found to increase human-to-human communication in households. Secondly at Tonsley campus, where the 'OrbIT' gaming device for children increased sibling-to-sibling interaction. Thirdly in Flinders Medical Centre, I observed the 'Lokomat' exoskeleton robot increasing the interaction between clinician and patient. These observations gave insight to specific relational benefits that robots could enable.

In terms of robot adoption, the experience of Zenkoukai where care staff were specifically trained to develop their flexibility and creativity, corresponded with the focus on problem-solving skills and creativity development in New Zealand nurse education. I concluded that such skills would be vital in enabling nurses to adapt and thrive in a world where robots may become increasingly prevalent.

2.3. What is Nursing and how might robots help?

In order to consider what role robots might play in the future delivery of nursing, it was important to first understand what nursing is. The definition of nursing is a dynamic one which continues to be debated (Raiesifar *et al.*, 2019, Jackson, Anderson and Maben, 2021). Consequently, key nursing organisations continue to grapple with definitions of what nursing is

> **Definition of Nursing**
> Nursing encompasses autonomous and collaborative care of individuals of all ages, families, groups and communities, sick or well and in all settings. Nursing includes the promotion of health, prevention of illness, and the care of ill, disabled and dying people. Advocacy, promotion of a safe environment, research, participation in shaping health policy and in patient and health systems management, and education are also key nursing roles. (ICN, 2002)

(Clark, 2003). The International Council of Nurses definition (2002) definition above emphasised the complexity and comprehensiveness of caring.

This notion of care was reiterated in Boykin and Schoenhofer's (1993) theory of nursing as caring, based on nursing knowledge and directed by ethical and spiritual principles and the responsibility to nurture caring. Even the Royal College of Nursing (RCN), which published eight Principles of Nursing Practice in 2010, focused on the how of care delivery, and as a result also failed to explain what nurses and nursing staff do. More recently these have been reviewed, with the terminology of nursing as a '*safety critical profession'* added, based on '*evidence-based knowledge, professional and clinical judgment'* (RCN, 2023) echoing Leary's (2023) description of a safety critical profession.

Media representations of nursing often oversimplify the profession, reducing it to physical tasks such as patient hygiene and dressing (Gillett, 2012). Additionally, some depictions portray nursing as a series of individualized tasks (Mudd *et al*., 2020). However, the emphasis on 'care' creates several issues. Firstly, the concept of 'care' is not unique to nursing, as it is used in other professional contexts (Parker, 1993. p.vii). Secondly, the meaning of 'care' can be open to interpretation and misunderstanding. Finally, focusing solely on the emotional and relational aspects of nursing work (Nelson and Gordon, 2006) risks understating the complexity of nursing work (Jackson, Anderson and Maben, 2021).

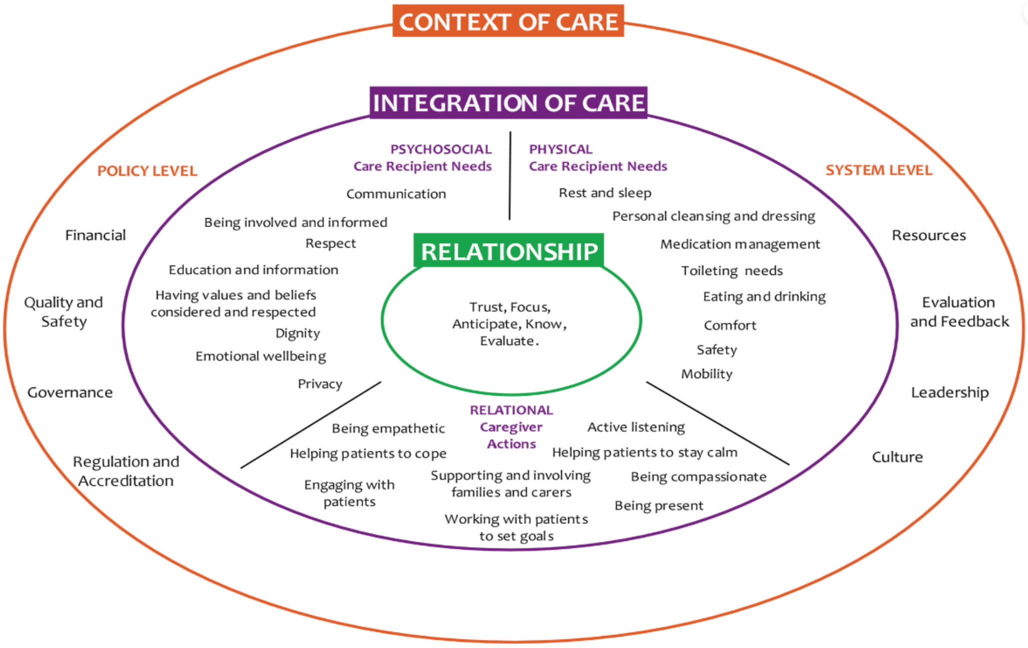
Jackson, Anderson, and Maben (2021) offered an alternative conceptual model of nursing labour built upon a comprehensive meta-narrative review (Jackson, Anderson, and Maben, 2021). Their model included cognitive, physical, emotional, and organisational labour as essential domains of nursing activity. Instead of focusing solely on tasks, this model emphasised the complex series of activities involved in nursing work. This is significant because it validates the often-hidden aspects of nurses' work, such as their thoughts, which are difficult to replicate. In the domain of cognitive labour, for instance, critical thinking, clinical reasoning, and clinical judgment are crucial skills. The concept of ‘cognitive stacking’ was introduced, which referred to nurses managing and reordering up to 15 simultaneous priorities at any given time (Potter *et al*., 2005a), while also shifting their attention every 6-7 minutes (Potter *et al.,* 2005b). These cognitive aspects of nursing labour correspond with the "thinking and linking" aspects of nursing practice that form the foundation of the nurse-patient relationship (Kitson, Muntlin-Athlin, and Conroy, 2014).

It is also apparent that within each classification of labour lies a set of interrelated activities that nurses undertake. Therefore, in order to consider the role of robots in nursing, this study necessarily needed to consider a granular set of activities. This is necessary, not least because nursing activity lists are already being used to consider robotic capability and functionality in a number of studies (Jang *et al.,* 2015; Turja *et al.,* 2017; Lee *et al.,* 2018).

Whilst there are a range of theories underpinning nursing, many have been criticised for not capturing the complex and multi-dimensional nature of fundamental care (Tierney, 1998; Colley, 2003) and neglecting patient safety and quality frameworks (Hughes, 2008). In response to care failures, such as the Francis report on nursing care at Mid Staffordshire Hospital (Francis, 2013), international nurse leaders developed a new mid-range theory called the Fundamentals of Care (FOC) framework (Mudd *et al*., 2020). As a member of the International Learning Collaborative, I contributed to the development of this framework. FOC details activities that address 12 basic human needs, including nutrition, mobility, rest-sleep, communication, hygiene, elimination, safety, physical comfort, emotional support, dignity, privacy, and respecting choice (Feo, Kitson, and Conroy, 2018).

These are organised into Psychosocial, Physical and Relational dimensions which appear within the purple ring of the framework in Figure 2.1.

Figure 2.1. Graphic of the Fundamentals of Care Framework



Content within image derived from Feo, R., Conroy, T., Jangland. E., Muntlin Athlin, Å., Brovall, M., Parr, J., Blomberg, K., and Kitson, A. (2017).

The FOC Framework also included organisational aspects and policy and leadership roles of nursing, rather than the cognitive domain of nursing work as identified by Jackson, Anderson, and Maben (2021). However, it represented a shift in thinking from discrete tasks to a comprehensive, integrated approach that considers multiple care needs simultaneously (Feo, Kitson and Conroy, 2018). While a review by Mudd *et al*., (2020) suggested the need for further development in the context of care, this is in line with the cognitive labour and complexity of nursing (Jackson, Anderson, and Maben, 2021). Despite the limitations of the FOC Framework, it provides a useful framework for discussing the potential role of robots in nursing.

When discussing the implications of robots in nursing, the theoretical contributions of Rozzano Locsin and Tetsuma Tanioka are particularly relevant. Locsin (2005) created a mid-range nursing theory that built upon Boykin and Schoenhofer's (1993), theory of 'Nursing as Caring'. Locsin's theory identified technology as a key tool for enabling nurses to gain a better understanding of patients as individuals. In turn, Tanioka (2017) extended Locsin's work by developing the Transactive Relationship Theory of Nursing (TRETON), which outlined a model for how healthcare robots and human caregivers could work together. The model emphasised the triad relationship between humans (nurses and patients) and machines, where nurses delegate tasks related to human care to robots. While both theories were still conceptual at time of publication, a nursing instrument has since been developed and tested to support Locsin's theory (Parcells and Locsin, 2011). More recently, Osaka (2020) published a "Model for the Intermediary Role of Nurses in Transactive Relationships with Healthcare Robots" which outlined the nurses' role in deploying robots. So, whilst the FOC model made no reference to technology or robots, Tanioka (2017) and Locsin (2005) explicitly considered the future delivery of nursing using robots. These works will be discussed later in this thesis in the discussion of this study's results.

2.4. What is the current application status of Robots?

2.4.1. Classification of Robots in Health and Social Care

In the previous chapter, discrepancies in the definition of robots were discussed, especially when it comes to classifying various types of robots. The most commonly quoted classification by Broeken, Heerink, and Rosendaal (2009), classified robots into two categories; rehabilitative and assistive social robots. This functional classification was reiterated by Robinson, Macdonald, and Broadbent (2014), who defined healthcare robots as machines that aim to promote or monitor health, help with tasks that are difficult to perform due to health problems, or prevent further health decline. They considered health in its broadest sense, including physical, mental, emotional, and psychological wellness, they also separated robots into two categories: rehabilitation robots and social robots. According to Broeken, Heerink, and Rosendaal (2009), a social robot has an interface that enables interaction, while a rehabilitation robot does not. They then further divided social robots into service-type robots or companionship robots. Service-type robots were designed to assist with mobility, household tasks, and health and safety monitoring, (Broeken, Heerink and Rosendaal, 2009), while companion robots prioritise interaction to improve quality of life, although they can also provide some assistance such as fetching and carrying (Robinson, Macdonald and Broadbent, 2015). Maalouf *et al*., (2018) categorised service robots with similar functions as a sub-group of assistive robots, rather than socially assistive robots (SARs).

Even within classifications, there was variation within categories. Khosravi and Gharpanchi (2016) classified companion pets as service robots, despite the fact that they lack any service capabilities, citing Paro, the robotic seal as an example. However, there was greater agreement on the broader classification of SARs. Mordoch *et al*., (2013) conceptualised SARs as a hybrid of assistive robot functions that provide physical assistance and social interactive robot functions. This term was commonly used throughout the literature.

2.4.2. Where are robots used in Health and Social care?

According to Kolpashchikov, Gerget, and Meshcheryakov (2022), robots were initially developed for industrial manufacturing and later adapted for healthcare in the 1960s-70s. The first surgical robot was designed to assist with instrument positioning in neurosurgery and was introduced in 1988 (Kwoh *et al*.,). The Da Vinci surgical robot was introduced in 1997 and has since undergone over 25,000 peer-reviewed evaluations, demonstrating its ability to improve surgical outcomes and surgeon performance (Shafer, Stewart and Pott, 2009). Rehabilitative robots (discussed in the next section) have also been heavily researched in hospitals (Morgan *et al*., 2022). Additional technologies identified in healthcare include telepresence, pharmacy, socially assistive, interventional, imaging assistance, disinfection, radiotherapy, and delivery and transport (Morgan *et al.,* 2022).

It's intriguing to note that Morgan *et al*., (2022) did not identify any research on nursing robots or nursing assistance robots, despite the fact that the global market for robotic nurse assistants was estimated at 923.91 million USD (United States Dollars) in 2021 and is projected to reach USD 3641.36 million by 2032 (Fact.MR 2022). However, exoskeletons, telepresence, socially assistive, delivery, and transportation robots all have potential applications in nursing and will be explored further below.

2.4.2.1. Exoskeleton and Rehabilitative robots

During the 1960s and 1970s, exoskeletons were introduced to assist paralysed individuals in walking (EduExo 2018). These devices were designed to support limb and muscle function and are commonly referred to as wearable technology or wearable robots if they have robotic functionality (Agras *et al.,* 2022). They were principally developed to compensate for physical disabilities or reduced function, such as walking or eating (Verrusio *et al*., 2018; Garces *et al.,* 2022). Whilst the majority of exoskeleton research focuses on rehabilitative robots (Pesenti *et al.*, 2021), this study excluded them because their primary purpose is related to physiotherapy rather than nursing.

Some exoskeletal devices have been developed to assist nurses and caregivers in lifting and handling tasks (Gilhooly, 2012; Kato, 2021). However, much of the literature on these functionalities is rooted in laboratory settings and frequently employs students rather than practising nurses with patients (Connor, 2021). This aligns with Papadopoulos, Kouloughlioti and Ali's (2018) assertion that most studies on robotics concentrate on the impact to the patient and not the impact on the professional.

2.4.2.2. Telepresence and Telemonitoring Robots

Remote monitoring (telemonitoring) and communication (telepresence) can be mediated through static computer systems but as video and audio capabilities have advanced, robots have been developed with these capabilities. Whilst telemedicine for real-time, face-to-face clinical consultation was first described in the form of an audio-link (Grundy *et al.,* 1977), robotic systems allow the health professional to move around the patient space, providing a more real experience (Vaughn, Shaw and Malloy, 2015, Mann *et al*., 2015). In terms of effectiveness, an early study found that only 25% of 80 telemedicine consultations were considered effective in terms of therapeutic effects, increased efficiencies, and technical usability (Ekland, Bowes and Flottorp, 2010). However, Bettinelli *et al*., (2015) argued that robotic telepresence could improve patient outcomes by improving the quality of discussion between healthcare staff and between patients and clinicians. Other authors point to the advantages of overcoming the issues of distance, cost of travel and health limitations to provide remote consultations (Vaughn, Shaw and Malloy, 2015; Sampsel, Vermeersch and Doarn 2015; Vermeesch, Sampsel and Kleman 2015).

During COVID-19, teleconsultation became centre stage (Latifi and Doarn, 2020) overcoming the challenges of social distancing through remote consultations (Singh *et al*., 2021) and remote relative visiting (Lociciro, Guillon and Bodet-Contentin, 2021). Telemonitoring was also found to be effective in monitoring COVID-19 patients at home although issues of data quality and unequal access to care were cited (Sprogis, Currey and Cosidine, 2019; Haveman *et al.,* 2022; Barbosa *et al.,* 2023).

The use of teleoperated robots, controlled by someone in a different location, has limitations when it comes to tasks that require manual dexterity (Koceski and Koceska, 2016). For instance, recording an ECG using a test robot was not as effective. However, not all tasks require manual dexterity. One such example is a robot dog that used camera sensors and algorithms to record respiratory rate, temperature, and oxygen saturation. Although it could not measure blood pressure, the accuracy of such functionality was being tested in 2020 as reported by Zahid. Additionally, the robot's functionality has been expanded to include a robotic arm, making hand-like manipulation and object retrieval possible (Amadeo, 2021). Earlier research by Back *et al.*, (2012) showcased the successful use of the NAO robot in answering call bells in a nursing home by navigating to the resident's room and transmitting images to the caregiver. However, some limitations were identified, such as the robot's walking speed, battery life, and stability (risk of falling over).

2.4.2.3. Fetching and carrying or courier robots

Service robots with fetching and carrying functions i.e. delivery of patient meals or linen, have been deployed in healthcare for over a decade (Hay, 2012). Over two decades ago Matsukuma *et al.*, (2000) reported on a robot that could autonomously deliver and collect patient food trays from a patient overbed table. Whilst positively evaluated, it was unclear how the robot managed the multiple positions of the bed table and navigated any objects on the table. More recent versions of meal delivery robots carry multiple food trays but generally require a human to assist with the last stages of the delivery (i.e. machine to table or eating surface).

2.4.2.4. Social Robots

Social robots are interactive robots that can autonomously communicate with people (Scoglio *et al.,* 2019). They are also referred to as companion robots (Broadbent, Stafford and Macdonald, 2009), socially assistive (Papadopoulos *et al.*,

2020) and commitment robots (Wada *et al*., 2003; Mordoch *et al*., 2013). Some robots support the mental health interventions such as: therapeutic robots, caring robots, mental health robots, and mental commitment robots. Studies have investigated the effectiveness of robots that aim to reduce depression, loneliness, stress, anxiety, and agitation, particularly in individuals with dementia. While there is no clear operational definition for these types of robots, the expected outcomes include improved social interaction and engagement, quality of life, sleep at night, and a positive immune response. These outcomes (supporting mental health and reducing depression, loneliness, stress and anxiety) are also relevant to hospital nursing (Davenport, 2005; Mordoch *et al.*, 2013; Moyle *et al*., 2018).

Numerous studies have highlighted the potential benefits of utilising technologies such as robotic pets (Broekans, Heerink and Rosendal, 2009, Katchouie *et al*., 2014; Abbott *et al*., 2019), but there are differing opinions surrounding their effectiveness. Different studies have produced various and sometimes even conflicting results. For example, both Moyle *et al.*, (2017) and Libin and Cohen-Mansfield (2004) found no evidence of reduced patient anxiety when using a robotic pet, but Petersen *et al.*, (2017) demonstrated a significant reduction in anxiety, as well as a decrease in the use of psychoactive and pain medications among the robot intervention group.

Other studies have reported improvements in agitation, depression, and sleep quality (Moyle *et al*., 2018; Pu *et al.,* 2021), whilst some like Thodberg *et al.*, (2016) found no impact. Physiological effects were also observed, such as reduced blood pressure after handling the Paro robot (Robinson, Macdonald and Broadbent, 2015), and positive impacts on immune response through a reduction in stress hormone (Wada and Shibata, 2006). Wada *et al.*, (2003) also demonstrated improved mood following three weeks interaction with a robot which was maintained over time (Wada *et al*., 2005).

The effectiveness of robotic pets in reducing agitation and increasing social interaction compared to static soft toys has been debated. A study by Libin and Cohen-Mansfield (2004), found that both a soft toy cat and a robotic cat called NeCoRo had similar effects, but residents preferred holding the robotic cat. However, the study only had nine participants and therefore results are not generalisable. Systematic reviews have also provided contradictory results, with Pu *et al.,* (2019) concluding no significant reduction in agitation from using robotic pets, while Lu *et al.*, (2021) suggested a significant reduction.

Similarly, one systematic review reported no statistically significant improvements in depression from the use of robopets (Abbott *et al.*, 2019). However, the systematic review by Saragih *et al.*, (2021) reported significant improvements from the same study by Joranson *et al*., (2015) and additional studies by Lee *et al.* (2020a) and Pu *et al.,* (2021). This could be due to the inclusion of cognitive programs and speech capability in the Lee *et al.,* (2020a) study, which used a penguin-like robopet named Bomy.

Overall, while there is a growing body of evidence on the effectiveness of robotic pets, conflicting findings across different methodologies suggest the need for further context-specific research and careful study selection in systematic reviews.

2.5. Robots in nursing

There were a number of studies looking at robot use in nursing including multiple scoping reviews across different contexts, several related to the care of older people, some related to all robotics/technology (Kangasniemi *et al.,* 2019; Papadopulous *et al.,* 2020). Some were not undertaken by nurses and omitted to search nursing databases. Despite this, the topic of robots in nursing was poorly defined (studies often conflated nursing with social care, and 'boundaries' differed according to geographical context and culture). To add to these difficulties of delineation, nursing was described across the different contexts of home, social and hospital.

These studies illustrate an increasing interest in the use of nursing robots as supplemental healthcare workers. Robots were described performing logistics and physically demanding tasks, as well as offering companionship and combat inactivity (Christoforou *et al.*, 2020). However, there was a lack of clarity in the literature on what constituted a nursing robot. For instance, the webpage on robots in nursing by Duquesne University (2020) aimed to attract potential nurses to the profession by detailing the 'nursing skills' of 'famous' nurse robots such as Dinsow, Paro, and Pepper. This is potentially concerning as some of these robots lacked limbs or speech, which raises questions about the central skills required for nursing. Paro or Pepper were amongst the most researched social robots in elder or aged care settings, but neither were designed, nor marketed as nursing robots. This suggested several unrealistic claims about these social robots, or a poor understanding of what nursing skills are.

Furthermore, while some robots have been labelled as nursing robots in the literature, they can only perform a small fraction of nursing activities. For instance, the teleoperated intelligent nursing assistant (TRINA) was reported to perform 60% of common nursing tasks, but only three of the identified 26 'common nursing tasks' involve patient contact. Most consisted of moving and handling objects like patient drinks, medication, and carts which the robot performed at a pace 20 times slower than a human nurse (Li *et al.*, 2023).

In some studies, the effectiveness of "nurse robots" was exaggerated. For instance, Pollack *et al.,* (2002), described "Pearl" as a nurse bot designed for care homes, but it only had two primary functions: providing verbal reminders for basic tasks and guiding people around the facility. Ahamed *et al.*, (2020), compared their nursing robot to a human nurse, claiming it to be more cost-effective. However, closer examination revealed that the robot only had two functions - a water dispenser and an automated medication drawer – and was unable to give either the water or medication directly to the patient. The assertion that a robot with such limited functionality could replace nursing time at a lower cost indicated a misunderstanding of the full range of nursing activities.

Recently, a manufacturer announced that a humanoid 'nurse robot' named "Grace" was going into production in 2022 (Cairns, 2021). This robot was an advanced conversational machine equipped with cameras and sensors that could take temperature, pulse, and determine if the patient was alert or not. However, it could not assist in the physical aspects of nursing and lacked the ability to interact physically. With limited assistive tasks the description of 'nurse robot' was problematic and highlighted a significant lack of understanding of the nursing role as such robots are unable to perform all aspects of patient care. This is akin to describing a car wheel as a car, whereas a car requires more than just wheels to function properly. On the other hand, the digital nurse assistant 'Moxi' was designed to reduce nursing time by providing a fetch-and-carry ability to deliver medication, documentation or patient belongings to other parts of the hospital. Although some articles describe Moxi (Paton and Cur, 2019) as a nursing robot, the manufacturers were clear that it functions as an assistant to nursing rather than a replacement.

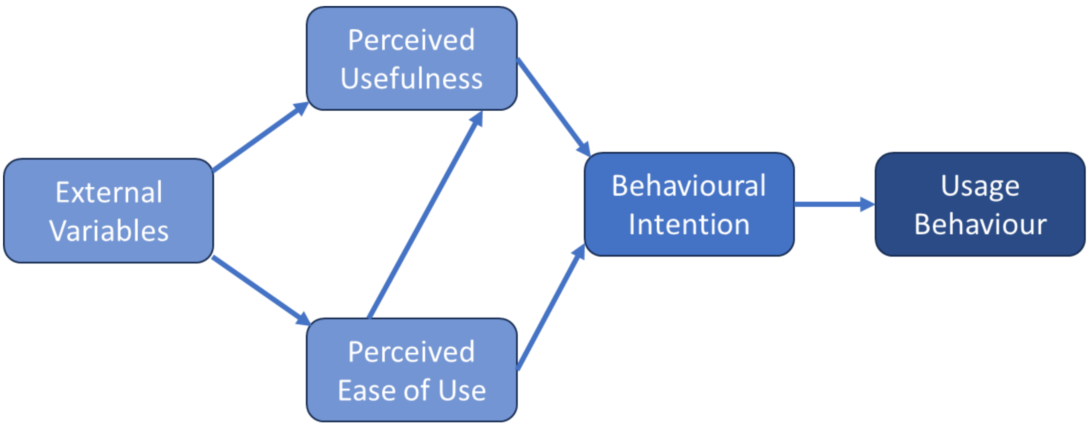
In healthcare settings, there was a significant amount of literature on surgical, rehabilitative, and telepresence robots. While there were some examples of social and service robots, nursing had only a few robots labelled as nursing robots. However, these robots have limited functionality, and their capability was often exaggerated. Furthermore, the existence of robots does not equate to their acceptance. Whilst robots were being developed, there were multiple factors that influenced acceptance and usage. This chapter will now consider the acceptance and adoption of robots commencing with a consideration of adoption theories.

2.6. Theories of Technology Adoption

Several models have been developed to try to explain and predict technology acceptance and adoption. Perhaps the earliest and most influential is the Technology Acceptance Model (TAM), developed by Davis in 1985 to predict use of computer technology (Silva 2015). Davis drew heavily on Fishbein's (1967) psychological theory of reasoned action and Fishbein and Ajzen's (1975) theory of planned behaviour for this motivation model of technology acceptance.

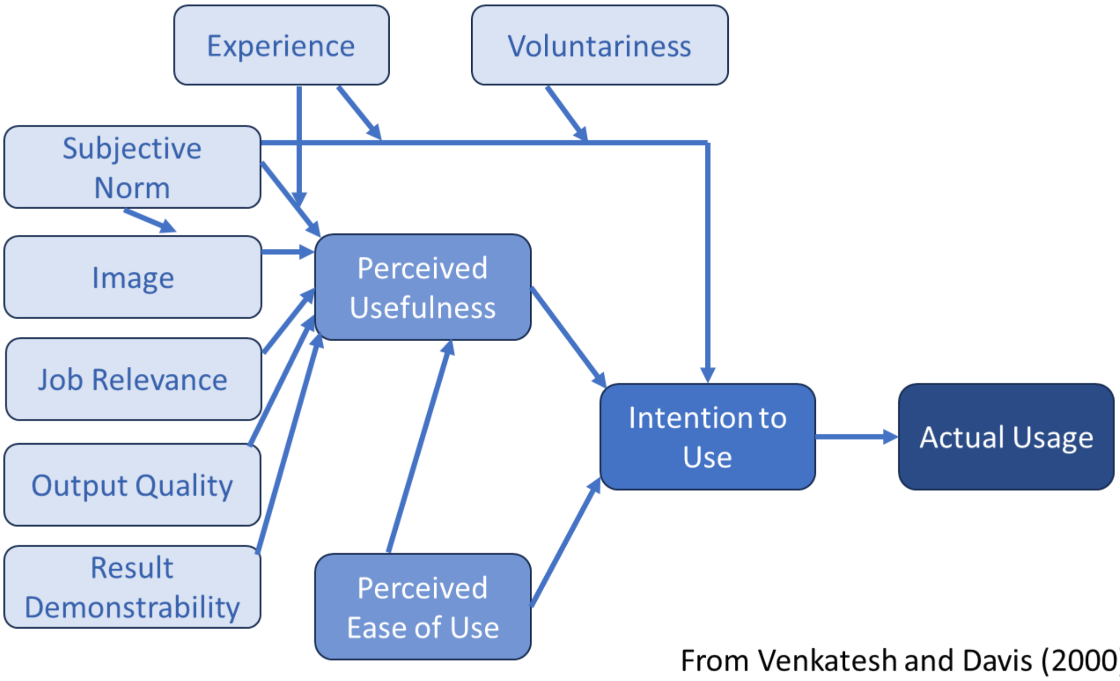
The first iteration of TAM combined 'perceived ease of use' of the technology and 'perceived usefulness' (which had a stronger effect), to create an intention to use the technology which in turn would predict actual use (Davis *et al.*,1989).

Figure 2.2. Technology Acceptance Model (TAM 1).



From Venkatesh and Davis (1996)

Figure 2.3. Technology Acceptance Model (TAM 2)



From Venkatesh and Davis (2000)

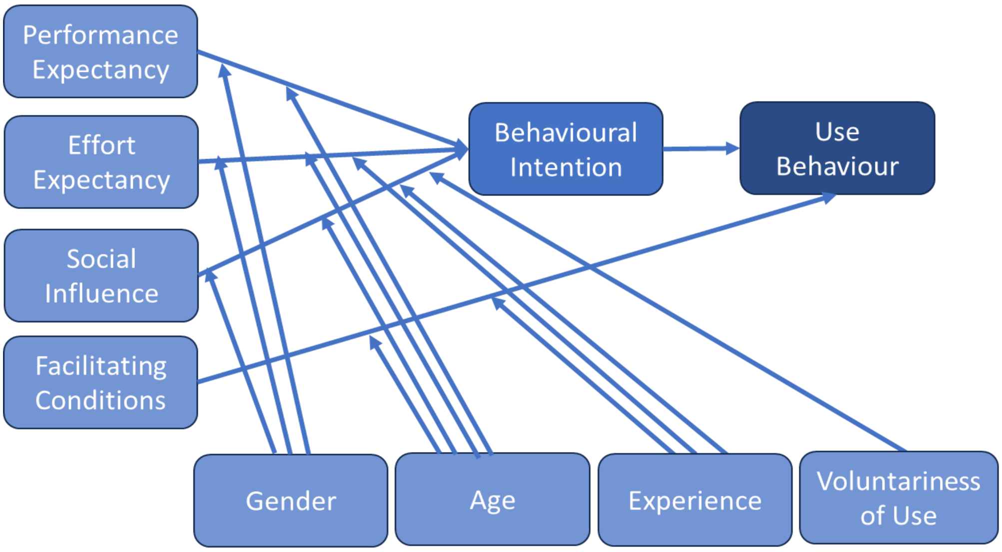
The second iteration: TAM 2, added attitude and moderators of experience and voluntariness and the subjective norm which is the perception of what the individual thinks others will think (Venkatesh and Davis, 2000). Whilst criticised for its deterministic assumptions (Bagozzi, 2007), it has been widely used across the health sector (Chutter, 2009; Rahimi, 2018). Although initially designed to predict the voluntary adoption of information technology, it has been used to consider the acceptance of wider technologies including robotics (e.g., Klarmer and Allouch, 2010; Shore, de Eyto and O'Sullivan, 2022).

Attitude has been shown to be a significant consideration for adoption (Sharp, 2007) and voluntariness is of particular relevance to health services since the use of technology is often mandated at the organisational level in order to improve effectiveness or efficiency, which in turn will affect adoption (Brown *et al*., 2002).

Subsequently Venkatesh *et al.,* (2003) brought together key components from TAM and other models of acceptance into a Unified Theory of Acceptance and Use of

Technology (UTAUT) which has also been used in subsequent research, e.g., Beuscher *et al.*, (2017). An extension to UTAUT was later published introducing additional factors for a consumer market, (Venkatesh, Thong and Xu, 2012). A recent electronic search revealed that both TAM 1 and 2 and UTAUT 1 and 2 have been used in healthcare research but there is no mention of TAM 3 (Rouidi *et al.*, 2022). TAM 3 and UTAUT 2 are reproduced as ***Appendix 2*** and ***3*** for reference.

Figure 2.4. Unified Theory of Acceptance and Technology Adoption (UTAUT 1)



From Venkatesh et al 2003)

Although not a theory as such, many studies have used Nomura and Kanda's (2003) early Negative Attitudes to Robots scale which reinforces the pivotal role of attitudes in determining robot acceptance. More recently Koverola *et al.*, (2022) developed a new instrument to measure general attitudes to robots building on the Negative Attitudes to Robots scale, arguing that positive attitudes are not simply the opposite of negative attitudes and can exist at both a personal and societal level. However, studies using this scale have yet to be published.

Technology acceptance theories contribute an understanding of general acceptance of technology but are not specific to robot technologies and the attitudes to robot scales are not specific to healthcare. Wider population attitudes to robots have been explored internationally as the next section describes.

2.7. General population attitudes to robots

Several factors have been found to influence people's acceptance of robots, including demographic characteristics such as age, gender, and level of education. Experience with robots and their appearance and level of autonomy also influence attitudes towards them.

A European population survey conducted in 2012 found that two-thirds of the 26,751 respondents were positive about the use of robots, even though only 14% had previous experience with them (Eurobarometer, 2012). A similar survey two years later yielded comparable results, with the UK having less exposure to robots than the European average but similar acceptance rates (Eurobarometer, 2015). In 2017, two-thirds of European respondents regarded digital technologies as having a positive impact on society, the economy, and their own lives (Eurobarometer, 2017). However, analysis of these results suggests a negative trend towards the use of robots in the workplace (Gnambs and Appel, 2019).

Nevertheless, the 2017 survey also confirmed that the more informed or experienced people are with technologies, the more likely they are to have a positive opinion about them and to trust them, despite concerns about job losses. A study by Johanson-Pajala *et al*., (2019) comparing attitudes across Finnish, German, and Swedish populations found that focus groups became more positive about robots as their knowledge improved.

Some studies suggested that user age influences robot acceptance, with older people less willing to use technology (Heerink, 2011; Chien *et al*., 2019). However, Gessl, Schlöglb and Mevenkamp, (2019) suggested the relationship between increasing age and technology aversion was more complex and Czaga *et al*., (2006) ascribed age-related findings to current use of technology and cognitive ability rather than age. Backonja *et al.*, confirmed these findings in their 2018 study of population attitudes, which found no difference in perceptions across age groups.

A number of different factors have been linked to robot acceptance such as educational background, pre-existing attitudes, previous exposure and gender. Heerink (2011) found that higher levels of education were linked to more positive attitudes to robots. However, Katz and Halpern, (2014) found individual's attitudes towards robots were strongly related to their views about the acceptability of having robots fulfil certain occupations in society. This may explain findings by Backonja *et al.*, (2018) that respondents were uncomfortable about robots caring for elderly or children. This discomfort was also seen in home care workers in the study by Rantanen *et al*., (2018) in which respondents (of whom 82% were nurses or practical nurses) were negative overall to robots undertaking caring activities. In contrast, Chen, Jones and Moyle (2019) found that their participants, which included 43% nurses, reported generally positive attitudes towards robots in long-term care, with 81.3% regarding robots as useful.

Exposure to robots has also been postulated to account for population differences in attitudes to robots, for example Coco, Kangasniemi and Rantanen (2018) found that fewer Japanese care workers were afraid that robots would endanger jobs, than their Finnish counterparts, which was attributed to exposure. This explanation concurs with Haring and Watanabe (2014) who concluded that Japan has significant exposure in the media to robots and their role. Venkatesh, Morris, and Ackerman (2000) suggested gender influences acceptance suggesting that women were more influenced by ease of use and men more influenced by attitudes, however their later study in 2005 could only replicate gender difference in older adults (Morris, Venkatesh, and Ackerman, 2005) suggesting that this may no longer be the case.

2.8. Robotic Appearance

The appearance of a robot is a key factor in acceptability (Hersh, 2015) and falls into three broad descriptions. Firstly, those that were designed to look like an animal, pet or baby, secondly those designed to look like a human, and thirdly robots with a machine-like appearance. Many are designed to be socially assistive and the design is an integral part of the social interaction. Robotic animals often resemble pet animals and were designed to mimic vulnerability, perhaps to avoid being perceived as threatening. Interestingly this group included a baby harp seal, bear and dinosaur all of which are unlikely to be domesticated. They may however invoke feeling of needing to look after the robot, as in the case of 'my real baby' robot which was introduced to a number of residential homes (Turkle *et al*., 2006).

The second type of appearance was that of humanoid or human-looking robots. Some were anthropomorphic or human-like with a head, torso and sometimes limbs. Given that robots are generally expected to inhabit a world created by humans for humans this shape is unsurprising and according to Christoforou *et al.,* (2020), well suited to the human environment. Humanoid robots were found in some studies to be preferred as they were perceived as easier to use and more capable of engaging in social activities (Iwamura *et al.,* 2011; Caleb-Solly *et al*., 2014). Iwamura's study of a shopping assistance robot found that the humanoid appearance was linked to the robot being perceived as a partner and conversation was enjoyable whereas the machine-like robot was perceived as a tool.

This corresponds with the study by Broadbent *et al*., (2013) who found that a more human-like face was perceived to have more mind and more personality. In addition to the physical appearance, the principal difference between animal-like and human-like robots was the use of language in humanoid robots and animal-like sounds such as purring in robotic animals. Other studies also found that the more human-like a robot appeared to be, the more acceptable it was until it looks almost identical to a human when the reaction changed to one of repulsion due to appearance. This phenomenon was labelled as the uncanny valley (Mori, 1970) and was thought to be due to the robot appearing too familiar. However, Destephe (2015) tested this whilst looking at gestures and found that attractiveness mitigated any impact of this uncanny valley. This supported findings of Bartneck *et al*., (2009); and Thompson, Tratton and Mc Knight (2011) who added human-like movement to the robot and then were unable to replicate the rejection response, suggesting that lack of movement contributed to the inhuman appearance of a human-looking robot. There may also be other differences in the robot's appearance as Ho, MacDorman and Promono, (2008) postulated. They conducted two experiments with the same robot; firstly, with exposed robotic parts, and secondly in full clothing, the latter eliciting a rejection response.

The third type of appearance is machine-like robots, although it must be acknowledged that several of the machine-like designs (whilst they might include wheeled platforms rather than legs), may have either animal-like or humanoid-like features such as faces, limbs and torsos. For users that envisaged socially assisted robots as machines, Vandemeulebrooke, Dierchx de Casterle and Gastmans (2018) argue that a machine-like appearance is preferred which creates the impression of superior performance (Prakash and Rogers, 2015). The variation in preference of appearance was clear with both negative and positive feelings being expressed to every possibility (Vandemeulebrooke, Dierchx de Casterle and Gastmans 2018). This suggests that preference on the basis of appearance was highly individual, and is linked not only to robot appearance but to robot behaviour, confirming Papadopoulos and Koulouglioti's (2018) work on culture, finding that people were more likely to accept robots that behaved closely to the user's culture, compared to those that did not.

2.9. Other factors influencing acceptance of robots

Robotic capability is a crucial factor in determining its adoption rate (Kijsanayotin, Pannarunothai and Speedie, 2009; Feil-Seifer and Mataric, 2011; Zhou, 2012). Alaiad and Zhou (2014) discovered that expectations of the robot's performance had a positive impact on 'users' willingness to use it. Among the tasks that respondents preferred the robot to be able to assist with were measuring, recording, and reporting vital signs, connecting the family with a doctor/therapist remotely, reminding patients to take their medication, monitoring medication, managing wounds, and tube feeding. The highest preference was for the robot to assist with measuring, recording, and reporting vital signs and connecting the family with a doctor/therapist remotely, both mentioned by 34.43% of respondents.

Reliability is also important in the adoption of robotic technology. A robot that can be relied upon is more likely to be accepted, while an unreliable one can hinder its adoption. This is a crucial aspect, as scholars such as Metzler, Lewis, & Pope (2016) and Maalouf *et al*., (2018) have raised concerns about the reliability of robots in nursing. Servaty *et al*., (2020) also highlighted the fear of malfunction as a significant obstacle to robot adoption, given that technical issues have been reported in several studies (Wu *et al.,* 2014; Hebesberger *et al.,* 2017; Rantanen *et al*., 2017; Bedaf *et al*., 2018). In addition, Kriz *et al*., (2010) and Beer *et al*., (2011)noted that a mismatch between expectations and actual capabilities of the robot negatively impacted acceptance, while Moon, Danielson and Van der Loos (2012) linked acceptance to the level of robot autonomy.

The unreliability of robots as data holders was also a widely discussed ethical issue in the literature (Peek *et al.,* 2014; Wu *et al.,* 2014; Glende *et al*., 2016). This concern included reticence about being monitored by robots, which could be perceived as an invasion of privacy, particularly if remote monitoring is the robot's primary purpose.

2.10. Chapter Summary

In summary, this chapter explored how robots have been used within health care and acceptance of this (though acceptance is not specific to health care). This is a fast-moving field and examples above are illustrative of the range of use of robots across health and social care. Robots in social care were also considered as the use of social robots in monitoring and social companionship functions are being introduced into hospitals. The efficiency of robots was sometimes overstated and the evidence on efficiency and effectiveness was not strong. In terms of acceptance of robots, appearance, capability and concerns around data handling were key factors that influenced the general acceptance of robots. Technology acceptance theories appear too broad to address the specifics of healthcare and studies on acceptance of robots are not specific to nursing. The following chapter reviews the specific literature related to nurses' perceptions on the use of robots in hospital nursing.

Chapter 3: Literature Review

3.1. Introduction to Literature Review

This chapter explores what is already known about nurse's perceptions of robot use in acute nursing through a review of the literature (Aveyard, Payne and Preston, 2016).

3.2. Rationale for Literature Review

This topic spans more than one professional field (i.e. nursing and robotics), therefore it was important that literature search was systematic and searched both nursing and relevant non-nursing databases, so that all available information is incorporated (Aveyard 2019). A key decision was to consider what type of literature review would be most helpful in answering the research question and setting the context for this research. Aveyard and Bradbury Jones (2019) point to a proliferation of papers on different methods of literature review over the last two decades (Bettany-Saltikov and McSherry, 2012; Coughlan, Ryan and Cronin, 2013; Aveyard, 2019 and Davis, 2016). Aveyard (2019) suggests that the literature review question may differ from the research question which was the case for this study as the research question comprised four concepts or topics: nursing, robots, hospitals and perspectives.

3.3. Methodology of literature review

Whittemore *et al.* (2014) identified five essential components of all knowledge synthesis methods:

- an explicit aim;
- development of a methodological protocol;
- comprehensive search strategies to find relevant research articles;

- a method of evaluating quality and potential risk of bias in individual studies; and
- explicit data collection and synthesis procedures.

A methodological protocol for the literature review was developed (reproduced as ***Appendix 4***) and these five components presented below.

3.4. Aim of Literature Review

The specific aims of the review were as follows (Drawn from Peters *et al.,* 2015):

- Clarify key concepts such as robot, service robot, nursing robot, companion robot and social robot
- Systematically search a broad area of evidence across nursing, electrical engineering and robotic development
- Identify the gaps in the knowledge base
- Report on the type of research and theoretical evidence available
- Report on the research methods and what this means for this UK nursing study.

3.5. Literature Review Questions

The literature review questions differ from the research question as they do not limit the literature to a future time frame. The review was undertaken to find out:

- What is known about nurses' perspectives/attitudes to robots in hospitals currently and
- What is the quality of this research and what gaps might there be?

Studies which capture nurses' perspectives (attitudes, views and opinions of nurses) on the use of robots in nursing were included.

3.6. Working title for the literature review:

> ***What are nurses' perspectives on robots in hospital nursing – an integrative review of quantitative and qualitative literature*.**

3.7. Definitions

Four keywords or concepts were included in the search criteria: Hospital, Robot and Nursing and Perspectives, the definitions for which are included in Table 3.1.

Table 3.1. Definitions of Terms for the Literature Review

Definitions for Literature review			
Robot	Nursing	Hospital	Perspectives
Robot will be defined as a technological object or machine with capability to move, sense and process information and act on the environment.	Care delivered by nurses or under the supervision of nurses or the practice by a nurse of providing care to a patient	An inpatient care facility employing nurses	Views, Attitudes, Opinions or quotes

3.8. Methodological Approach

3.8.1. Types of literature to be included in the Literature Review

Phases two and three of the research study gathered nurses' opinions on the future role of robots. Opinion pieces and practice literature, although relevant to the topic are limited to a single perspective and unlike research, the motive or bias may be unclear. In contrast, research sought to gather multiple opinions and consequently has only included research papers. It is unlikely that fully autonomous robots will be developed within the next 15 years, and therefore the study explored nurses' perceptions regarding all levels of robotic autonomy. Although teleoperated robots are currently being used for surgical procedures in operating theatres, surgical robots were not included in this study as they do not operate independently and are related to medical, rather than nursing practice. Additionally, literature about robotic scrub nurses was excluded as they have a distinct purpose of assisting in surgery rather than providing nursing care. It was also recognised that the global literature often does not distinguish nursing from social care, so specific search terms and a thorough examination of titles, abstracts, and full texts was undertaken to determine relevance.

3.8.2. Decision to undertake an Integrative Literature Review

Given that a number of scoping reviews exploring the wider context of robots and nursing had been identified, a further scoping review was not required. However, the reference lists for each scoping review were scrutinised and revealed a few papers related to nurses' perceptions. The process of integrative review enables the consideration of the quality, content and analysis of both qualitative and quantitative literature (Whittemore and Knafl, 2005) and was considered most appropriate to explore nurses' perceptions of robotic technologies in hospital nursing. Furthermore, the knowledge synthesis aspects of an integrative review offered the opportunity to better advance practice, research, and policy (Whittemore *et al.*, 2014) which met the aims of this study.

3.8.3. Search Process

1. Initial scoping searches (analysis of text words in title and abstract in one database) were undertaken in the Cumulative Index of Nursing and Allied Health Literature (CINAHL) database. This wide database of nursing and allied healthcare research was thought to give a good overview of the relevance of search terms and provides wide coverage of Nursing and Allied Health Literature of the Western world. Initial searches suggested that searching on truncated search terms robot* AND nurs* (to capture nurse, nurses and nursing) OR healthcare would yield too many records (over 744,000). Searching on just Robot* and Nurs* yielded 956 records which was more manageable. Wallace and Wray (2016) categorise literature into four types and this initial search yielded all four types: theoretical literature, research literature (both qualitative and quantitative), a large number of opinion pieces which Wallace and Wray

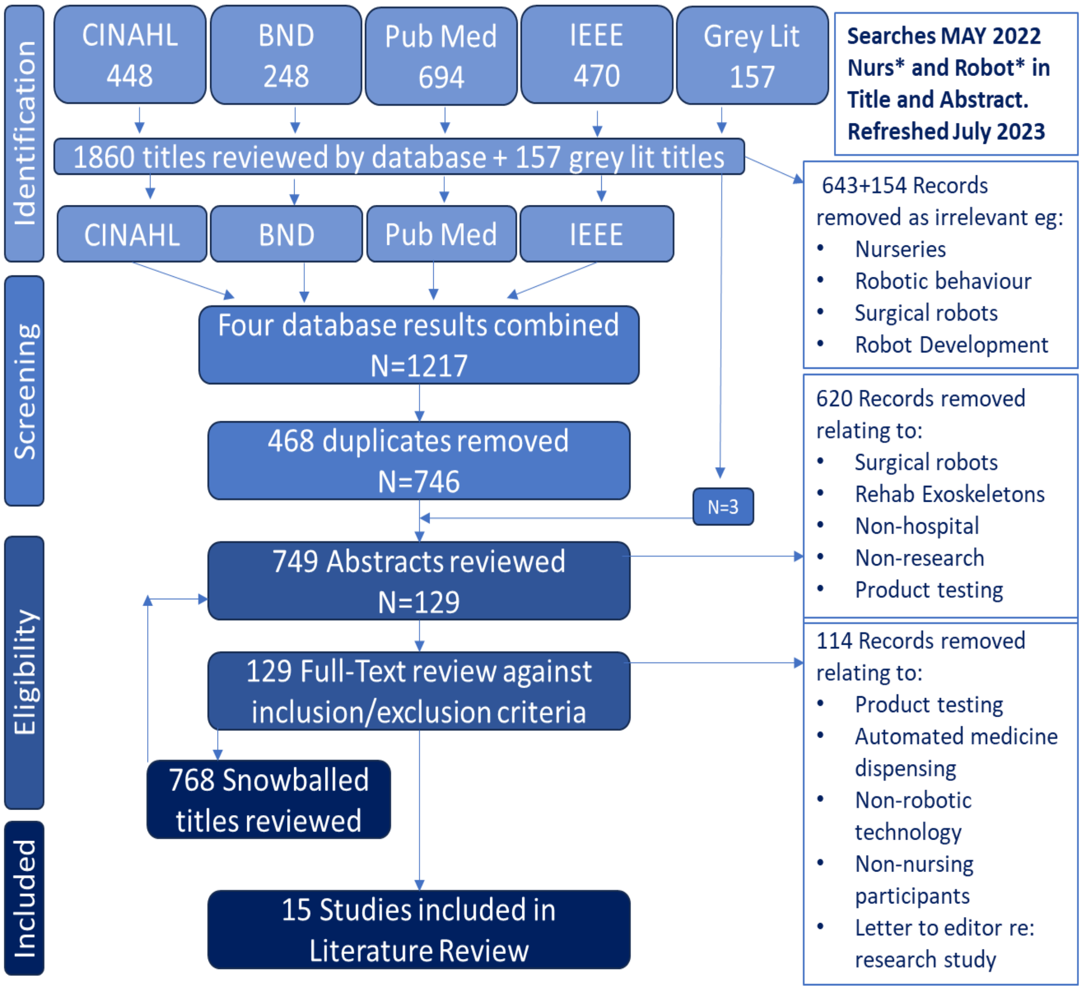
(2016) would label practice literature and some examples of policy literature such as a white papers or position documents. Initially all types of literature were skim read.

2. A second set of searches (presented below) using the narrowed search terms was undertaken across four databases searching on nurs* and robot* in the Abstract and Title. Several key studies had already been identified (as part of the research approval process) and these later searches successfully identified each of those studies (confirming that the narrowed searches were still identifying the most relevant studies). The rationale for the databases was as follows: the British Nursing Database (BND) was searched as this research is UK related and BND might identify references about UK practice that are missed by CINAHL. Pub Med was used because it is wider than nursing and may locate research related to wider healthcare where the terms nurse or nursing have not been used. The Institute of Electrical and Electronics Engineers (IEEE) database was included because it provides access to electrical and computational engineering research where much of the robotic development literature is first published.
3. Snowballing of references from all selected studies and all previous scoping or literature reviews was conducted and an additional 768 records were reviewed. This was because of the wide diversity of publications across a number of disciplines such as nursing, technology, robotics and electrical engineering.
4. Following a repeat set of searches in May 2023 and July 2023 (following the same process), alerts were set up on each database so that new literature could be reviewed. Grey literature databases (EBSCO, EThOS, and NDLTD) were also searched in May 2022 and August 2023, using the terms robot* AND nurs*. This contributed a further 157 records which were reviewed by title (excluding 154), three abstracts were reviewed and also excluded.

3.9. Review Process

The review process included combining all records from the 4 databases and removing duplicates using End Note. Record abstracts were reviewed against the inclusion and exclusion criteria and excluded studies were removed before conducting a full text review on remaining records. All literature reviews and selected papers were read in full and their reference list titles reviewed (snowballed) against inclusion/exclusion criteria. The illustration in Figure 3.1. presents the number of records found and reviewed according to the Preferred Reporting Items for Systematic Reviews (Moher et al., 2009).

Figure 3.1. Preferred Reporting Items for Literature Review



3.9.2. Selection Criteria

The table below identifies the inclusion and exclusion criteria for the literature review and gives the rationale for each.

Table 3.2. Inclusion and Exclusion Criteria for Literature Review

Table: Inclusion and Exclusion criteria for the Literature Review		
Inclusion	**Exclusion**	**Rationale**
Literature related to nurses **perceptions, attitudes and preferences** for robots in hospital nursing including: social robots in hospitals, robotic delivery of nursing care, telepresence robots (in nursing), robotic exoskeletons (for nurses or patient mobility)	Studies where the majority of participants are not nurses or where nurses' perceptions are not included	The key focus of this study is focused on the perspective of nurses so studies where participants are nurses are included and those where nurses perspectives are a small part of the sample or participants are not nurses are excluded. Telepresence robots may assist with the delivery of non-physical nursing care such as enhanced care Exoskeletons may be an area of robotic development relevant to nursing as lifting assistance.
Full paper available in English		To be able to access the article and understand the meaning (translation software can help but the meaning is often less clear)
	Literature related to medical and operative robotics	Peri-operative robotics are teleoperated robots –so low of degree of robotic autonomy, operated by doctors and not related to delivery of nursing care
	Telepresence robots for medical remote consultation	Refers to medical practice rather than nursing practice
	Telepresence robots used for nursing education purposes.	Relates more to education rather than nursing practice.
	Robotic patients used in nurse education	Education Robotics are usually teleoperated. Aim is to provide a lifelike patient rather than assist in clinical practice
	Socially assistive robots or commitment robots or robots in homecare and social care settings	Social robots providing social support less relevant to hospital nursing. Important to read abstract/full text as some authors do not distinguish between nursing care and social care
	Exoskeletons used for rehabilitation	More related to physiotherapy than nursing
	Robotic Pharmacy – Automated Dispensing Cabinets	Include any studies where robots administer medication to patients but exclude robotics limited to storage or dispensing medication. Dispensing cabinet is not defined as a robot
	Robotic information processing such as **RPA** and software support	Robots are likely to be equipped with AI but this study is narrowed to robots rather that wider technology such as AI without embodiment to enable nursing delivery.
	Literature related to technology that doesn't include robotics or robots	To focus the review towards autonomous robots that may be able to contribute to delivery of nursing.

Fifteen papers were selected for inclusion which are listed overleaf, each of these included the views, perceptions or opinions of nurses.

Table 3.3. Papers selected for Inclusion

Table: Papers included in Literature Review			
Authors	**Date**	**Name of Study**	**Publication**
Chang, HY., Huang, TL., Wong, MK., Ho, LH., Wu, CN., Ching, CI.	2021	How Robots Help Nurses Focus on Professional Task Engagement and Reduce Nurses' Turnover Intention	Nursing Scholarship
Christoforou, E., Avgoutsti, S., Ramandi, N., Novales, C., Panayides, A.,	2020	The upcoming role for Nursing and Assistive Robotics: Opportunities and Challenges Ahead	Frontiers in Digital Health
Ergin, E., Karaarslan, D., Sahan, S., Yucel, SC.	2022	Artificial Intelligence and robot nurses: From Nurse Manager's perspective: A Descriptive cross-sectional study	Journal of Nursing Management
Fuji, S., Date, M., Nagai, Y., Yashukara, Y., Tanioka,T., Ren, F.	2011	Research on the possibility of humanoid robots to assist in medical activities in nursing homes and convalescent wards	Institute of Electrical Engineering & Engineers
Ismail, S., Subu, MA., Al-Yateem, N., Alkhawaldeh, MY., Ahmed, FR., Dias, JM., AbuRuz. ME., Saifan, AR., Marzouqi, AA; Hijazi, HH., Alshabi, MQ., Rahman, SA.	2023	Using robotic technology in intensive care units: A qualitative exploration of nurses' perspective in Indonesia	Institute of Electrical Engineering & Engineers
Jang, SM., Hong,YJ., Lee, K., Kim, S., Chiến, BV., Kim, J.	2021	Assessment of User Needs for Telemedicine Robots in a Developing Nation Hospital Setting.	Telemedicine and e-Health
Jin, M., Kim, J.	2020	A survey of nurses' need for care robots in children's hospitals: combining robot-care, Game-care and Edu-care.	Computers, Informatics and Nursing
Lee, JY., Song, YA., Jung, JY., Kim, HJ., Kim, BR., Do, HK., Lim, JY.	2018	Nurses' Needs for care robots in integrated nursing care services	Journal of Advanced Nursing
Lee, H., Piao, M., Lee, J., Byan, A., Kim, J.	2020b	The Purpose of Bedside Robots. Exploring the Needs of Inpatients and Healthcare Professionals	Computers, Informatics and Nursing
Lee, JH., Lee, JM., Hwang, J., Kim, M., Kim, DH., Lee, JII., Nam, K., Han, IH.	2022	User perception of medical service robots in hospital wards: a cross-sectional study	Journal of Yeungham Medical Sciences
Liang, HF., Wu, KM., Weng, CH., Hsieh, HW.	2019	Nurses' Views on the Potential Use of Robots in the Paediatric Unit	Journal of Paediatric Nursing
Liao, GY., Huang, TL., Wong, MK., Shyu, YI., Ho, LH., Wang, C., Cheng, TCE., Teng, CI.	2023	Enhancing Nurse-Robot Engagement: Two wave study	Journal of Medical Internet Research
Nielsen, S., Langensiepen, S., Madi, M., Ellisen, M., Stephan, A., Meyer, G.	2022	Implementing ethical aspects in the development of a robotic system for nursing care: a qualitative approach.	BMC Nursing
Turja, T., Van Aerschot, L., Sarkikoski, T., Oksanen, A	2017	Finnish healthcare attitudes towards robots	Nursing Open
Zrinyi, M., Pakal, A., Lampeck, K., Vass, D., Ujvarine, A. Betlehem, J., Olah,A.	2022	Nurse preferences of caring robots: A conjoint experiment to explore most valued robot features	Nursing Open

3.10. Data Extraction:

Table 3.4. details the data extraction for each of the selected studies:

Table: Data extraction items for selected papers			
Title	Year	Authors	Authors Background
Study Purpose/ RQ	Number of Participants	Population	Sample
Study Method	Definitions	Country	Analysis
Findings	Conclusions	Limitations	Additional Limitations

3.11. Quality Appraisal

Whittemore and Knafl (2005) emphasise the importance of assessing the quality of the studies, and the aim of the quality appraisal was to give an indication of the limitations of the current research literature, rather than to use the quality appraisal to exclude some research papers on the basis of poor quality. It was important that quality appraisal criteria could accommodate both qualitative and quantitative studies and the framework developed by Kangasniemi, Karki and Voutilainen (2019), was used as it provided an integrated overview of both qualitative and quantitative literature. This framework drew from the work of Caldwell, Henshaw and Taylor (2011), Gifford *et al*., (2007) and Greenhalgh *et al*., (2004). Additional elements were added for this study: definition of concepts and evaluation of generalisability and transferability.

The quality appraisal criteria were used to aid the better understanding of the research and its strengths and weaknesses, rather than to exclude papers on quality grounds. Table 3.5 illustrates this appraisal and shows that whilst most studies were of sound quality there were some gaps, particularly in the quantitative studies. The criteria are coloured as follows: all study criteria in pale blue; qualitative criteria in white; and quantitative criteria in darker blue.

Table 3.5. Quality Appraisal of Selected Papers

Table: Quality Appraisal of Selected Papers	Chang et al. 2021	Christoforou et al. 2020	Ergin et al. 2022	Fuji et al. 2011	Ismail et al 2023	Jang et al. 2021	Jin and Kim. 2020
Does the title reflect the content?	N	N	Y	Y	Y	Y	Y
Are Authors Credible?	Y	Y	Y	Y	Y	Y	Y
Was the rationale for the research clearly stated?	Y	Y	Y	Y	Y	Y	Y
Were the Aim and Objectives of Research clearly presented?	Y	Y	Y	Y	Y	Y	Y
Was theoretical framework/literature review comprehensive?	N	Y	Y	N	N	N	Y
Was background up to date?	Y	y	Y	N	Y	Y	N
Was the study design appropriate for the research question?	Y	Y	Y	Y	Y	Y	Y
Was methodology clearly identified?	Y	Y	Y	Y	Y	Y	Y
Was methodology clearly justified?	Y	N	Y	N	N	Y	Y
Were ethical issues clearly identified and addressed?	Y	NK	Y	NK	NK	Y	Y
Was ethical approval sought and received?	Y	N	Y	Y	NK	Y	Y
Was informed consent obtained?	Y	NK	Y	Y	NK	Y	Y
Were results presented in a clear way?	Y	Y	Y	Y	Y	Y	Y
Was the discussion comprehensive?	N	Y	Y	Y	N	Y	Y
Were the conclusions clearly presented?	Y	N	Y	N	Y	Y	Y
Were the conclusions comprehensive?	N	Y	N	N	N	N	N
Was the concept of Robots clearly defined?	Y	Y	N	N	N	N	N
Was the concept of Nursing clearly defined?	N	N	N	N	N	N	N
Was the content of the study clearly described?					N		Y
Was the selection of participants clearly reported?					Y		Y
Were sufficient cases included?					Y		Y
Was data collection appropriately reported?					N		Y
Was the data analysis clearly reported?					N		Y
Was sufficient data presented?					N		N
Were the credibility and confirmability clearly addressed?					N		N
Were the author's positions clearly stated?					N		N
Are the results transferable?					N		Y
Was the population clearly identified?	Y	Y	Y	Y		Y	Y
Was the sampling method clearly reported?	Y	Y	Y	Y		Y	Y
Was the size of the sample clearly reported?	Y	Y	Y	N		Y	Y
Was the instrument sufficiently described?	Y	N	Y	Y		Y	N
Was the instrument validity and reliability clearly stated?	N	N	Y	N		N	N
Was the data collection appropriately reported?	Y	N	Y	N		Y	Y
Was the response rate reported?	Y	N	Y	Y		N	Y
Was the data analysis clearly reported?	Y	Y	Y	Y		Y	Y
Are results generalisable?	N	N	N	N		N	Y

Table: Quality Appraisal of Selected Papers (Cont)	Lee et al. 2020b	Lee et al. 2022	Liang et al. 2019	Liao et al. 2023	Nielsen et al 2020	Turja et al 2020	Zrinyi et al 2022
Does the title reflect the content?	Y	N	Y	N	Y	Y	Y
Are Authors Credible?	Y	Y	Y	Y	Y	Y	Y
Was the rationale for the research clearly stated?	Y	Y	Y	Y	Y	N	Y
Were the Aim and Objectives of Research clearly presented?	Y	Y	Y	Y	N	Y	Y
Was theoretical framework/literature review comprehensive?	N	N	Y	N	N	Y	Y
Was background up to date?	Y	N	Y	N	Y	Y	Y
Was the study design appropriate for the research question?	Y	N	Y	N	Y	Y	Y
Was methodology clearly identified?	Y	Y	Y	Y	Y	Y	Y
Was methodology clearly justified?	N	N	N	Y	Y	N	Y
Were ethical issues clearly identified and addressed?	N	Y	Y	Y	Y	NK	Y
Was ethical approval sought and received?	NK	Y	Y	Y	Y	NK	Y
Was informed consent obtained?	Y	Y	Y	Y	NK	Y	Y
Were results presented in a clear way?	Y	Y	Y	N	Y	N	Y
Was the discussion comprehensive?	Y	Y	Y	N	Y	Y	Y
Were the conclusions clearly presented?	Y	N	Y	N	Y	Y	Y
Were the conclusions comprehensive?	Y	N	Y	N	N	N	N
Was the concept of Robots clearly defined?	N	N	N	N	N	Y	N
Was the concept of Nursing clearly defined?	N	N	N	N	N	N	N
Was the content of the study clearly described?	Y	Y	Y		Y		
Was the selection of participants clearly reported?	Y	Y	Y		Y		
Were sufficient cases included?	Y	Y	Y		Y		
Was data collection appropriately reported?	Y	Y	Y		Y		
Was the data analysis clearly reported?	Y	Y	Y		Y		
Was sufficient data presented?	Y	Y	Y		Y		
Were the credibility and confirmability clearly addressed?	Y	N	Y		N		
Were the author's positions clearly stated?	Y	N	Y		Y		
Are the results transferable?	Y	Y	Y		N		
Was the population clearly identified?	Y	Y		Y		N	Y
Was the sampling method clearly reported?	Y	Y		Y		Y	Y
Was the size of the sample clearly reported?	Y	Y		N		Y	Y
Was the instrument sufficiently described?	Y	Y		N		Y	N
Was the instrument validity and reliability clearly stated?	N	Y		N		N	N
Was the data collection appropriately reported?	Y	Y		Y		Y	Y
Was the response rate reported?	Y	Y		Y		N	N
Was the data analysis clearly reported?	Y	Y		Y		Y	Y
Are results generalisable?	N	N		N		N	Y

3.12. Synthesis

3.12.1. Methods and purpose of selected studies

The following tables (3.6 and 3.7) give an overview of each studies purpose and methods and the limitations or gap in the literature in terms of this study.

Table 3.6. Study purpose and methods

Table: Study Purpose and Research Question			
Authors /Year	**Name of Study**	**Study Purpose**	**Research Question /Aims**
Chang, HY., Huang, TL., Wong, MK., Ho, LH., Wu, CN., Ching, CI. (2020)	How Robots Help Nurses Focus on Professional Task Engagement and Reduce Nurses' Turnover Intention	To examine how robot-enabled focus on professional task engagement and robot-reduced non-professional task engagement are related to nurses' professional turnover intention	To clarify how robots help nurses focus on professional task engagement and therefore reduce their turnover intention
Christoforou, E., Avgoutsti, S., Ramandi, N., Novales, C., Panayides, A., (2020)	The upcoming role for Nursing and Assistive Robotics: Opportunities and Challenges Ahead	To provide an overview of nursing landscape and assistive robotics, highlighting the benefits of adoption of solutions	To capture nursing professionals' views on different aspects of mobile robotic solutions
Ergin, E., Karaarlan, D., Sahan, S., Yucel, SC (2022)	Artificial Intelligence and robot nurses: From Nurse Managers perspective: a descriptive cross-sectional study	Nurse managers play a crucial role in advocating the use of robot nurses and AI so determining their thoughts and concerns is of great importance	To identify nurse managers' opinions on artificial intelligence and robot nurses
Fuji, S., Date, M., Nagai, Y., Yashukara, Y., Tanioka,T., Ren, F. (2011)	Research on the possibility of humanoid robots to assist in medical activities in nursing homes and convalescent wards	To find out whether there are any duties humanoids can undertake and what is required of humanoids to undertake these functions	To clarify what image or impression nurse and care staff working in nursing homes and convalescent wards has of humanoid robots
Ismail, S., Subu, MA., Al-Yateem, N., Alkhawaldeh, MY., Ahmed, FR., Dias, JM., AbuRuz. ME., Saifan, AR., Marzouqi, AA; Hijazi, HH., Alshabi, MQ., Rahman, SA. (2023)	Using robotic technology in intensive care units: a qualitative exploration of nurses' perspective in Indonesia	Adoption of a delivery robot in ICU	To determine the perspective of Nurses regarding the use of robots in patients in the intensive care unit
Jang, SM., Hong,YJ., Lee, K., Kim, S., Chiến, BV., Kim, J. (2021)	Assessment of User Needs for Telemedicine Robots in a Developing Nation Hospital Setting.	To investigate the needs of medical users of telemedicine to encourage international co-operations and development	To consider the perceived needs of end users of new systems including robots to ensure quality of care and positive user experience.
Jin, M., Kim, J.(2020)	A survey of nurses' need for care robots in children's hospitals: combining robot-care, Game-care and Edu-care.	To investigate the nurses' need of care robots in children's hospitals and to help develop care robots.	To investigate the need for care robots-integrating robot-care, game-care and edu-care for nurses who have worked at a general hospital for 6 months or more
Lee, JY., Song, YA., Jung, JY., Kim, HJ., Kim, BR., Do,HK., Lim, JY. (2018)	Nurses' Needs for care robots in integrated nursing care services	To determine the need for care robots among nurses and to suggest how robotic care should be prioritised in integrated nursing care services	To identify priorities for robotic case in integrated nursing services

Table: Study Purpose and Research Question (continued)			
Authors	**Name of Study**	**Study Purpose**	**Research Question /Aims**
Lee, H., Piao, M., Lee, J., Byan, A., Kim, J.(2020)	The Purpose of Bedside Robots. Exploring the needs of Inpatients and Healthcare Professionals	To identify the necessary aspects and functions of bedside robots for inpatients, thereby providing basic data for constructing actual AI systems and evaluating effectiveness	To better understand needs of inpatients and health professionals & how bedside robots could fulfil these needs To identify issues in implementation of technology
Lee, JH., Lee, JM., Hwang, J., Kim, M., Kim, DH., Lee, JII., Nam, K., Han, IH. (2022)	User perception of medical service robots in hospital wards: a cross sectional study	To identify user perceptions of medical service robots	To investigate user perceptions, need and possible problems for medical service robots
Liang, HF., Wu, KM., Weng, CH., Hsieh, HW. (2019)	Nurses' Views on the Potential Use of Robots in the Paediatric Unit	The aim of this study was to explore nurses' views on the potential use of robotics in the paediatric unit.	To analyse the answers to 1.How do paediatric nurses describe the roles of robotics in clinical practice? 2.What impacts do they associate with the use of robotic care in the paediatric unit?
Liao, GY., Huang, TL., Wong, MK., Shyu, YI., Ho, LH., Wang, C., Cheng, TCE., Teng, CI. (2023)	Enhancing Nurse-Robot Engagement: Two wave study	To find out how the benefits and robot maintenance influence nurse -robot engagement	To examine how robot benefits, robot maintenance and nurses' personal innovativeness impacts nurses' attitudes towards robots and nurse -robot engagement
Nielsen, S., Langensiepen, S., Madi, M., Ellisen, M., Stephan, A., Meyer, G. (2022)	Implementing ethical aspects in the development of a robotic system for nursing care: a qualitative approach.	To explore ethical risks and requirements relevant to the PfleKoRo system	What ethical risks and requirements must be considered when developing the robot?
Turja, T., Van Aerschot, L., Sarkikoski, T., Oksanen, A. (2017)	Finnish healthcare attitudes towards robots	To examine healthcare professionals' experiences with robots and how these experiences associate with the general view of robots or robot acceptance at work.	To answer question "how prepared are healthcare professionals to take robots as their assistants in terms of experience & acceptance?"
Zrinyi, M., Pakal, A., Lampeck, K., Vass, D., Ujvarine, A. Betlehem, J., Olah,A. (2022)	Nurse preferences of caring robots: A conjoint experiment to explore most valued robot features	To extend existing knowledge about nurses' preferences for caring robots by evaluating and jointly weighing multiple robot attributes	To assess what characteristics of caregiving robots nurses like and dislike and develop a model of most and least preferred robot dimensions

Table 3.7. Country of Study, Methods and Limitations

Table: Country of Study, Methods and Limitations				
Authors/ /Country	**Methods**	**Participants**	**Type of Analysis**	**Key Limitations (in terms of this study)**
Chang et al., (2020) Taiwan	Two wave Survey	331 nurses working in operating theatres	Structural Equation Modelling	Study is not future focused and use of questionnaire limited the items to those already identified, states a focus on bedside nurses but has a theatre focus.
Christoforou et al., (2020) Cyprus	Questionnaire Survey (developed by Focus Groups)	115 Students/ staff and alumni of whom 80% were nurses	Key Observations extracted'	Examines how nurses might react to the introduction of robots but doesn't identify the activities or roles that robots might undertake
Ergin et al., (2022) Turkey	Quantitative descriptive study	326 nurse managers	Statistical Analysis	The study doesn't detail what the robots might be able to do or how the robots could reduce nursing workload. Focuses on the impact /perceptions only. Conflates AI and robot nurses
Fuji et al., (2011) Japan	Questionnaire survey	939 staff: (224 nurses, 173 practical nurses, 196 Care workers & 113 Assistant nurses)	Statistical analysis	Findings are limited by the pre-populated items and a number of the evaluation items were not mentioned again in the study. Twelve year old study only considers some selected aspects of nursing – also only considers humanoid robots
Ismail et al., (2023) Indonesia	Interviews	10 ICU nurses (6 male)	Thematic Analysis	Small sample size, only refers to ICU nurses and possible gender bias. Interview questions and data capture method unclear – poor quality reporting
Jang et al., (2021) Vietnam	Questionnaire Survey	74 Nurses and 43 Doctors	Descriptive Statistical Analysis	Quantitative study is limited to telepresence capability Not known how questionnaire was designed /validated ie includes video and image play but not respiratory rate. Mixes responses nursing + doctors
Jin and Kim (2020) Korea	Mixed Method	198 Nurses (quantitative) and 12 (qualitative research)	Statistical analysis and qualitative content analysis	Focused on children's care but parallels with adult care and this included 12 nurses interviews. Childrens needs may differ from staff needs.
Lee et al., (2018) Korea	Cross Sectional Survey	302 Registered Nurses	Descriptive statistical Analysis	Possible gender bias (all participants female but 5.7% Korean nurses are male). Surveys activities but limited in relational aspects of care, of medication. No rationale.

Table: Country of Study, Methods and Limitations (continued)				
Authors	**Methods**	**Participants**	**Type of Analysis**	**Key Limitations (in terms of this study**
Lee et al., (2020) Korea	Mixed method. Online survey and focus group interviews	90 Healthcare Professionals (56.7% nurses), FG of 5 nurses (+4 Drs)	Statistical Analysis of questionnaire and Thematic Analysis of Focus Groups	Used focus group but looked at a very specific type of robot which limits the activities. interviews but number and make up of the focus groups is not reported
Lee et al., (2022) Korea	Survey	100 patients, 102 doctors and 116 nurses	Statistical Analysis	Study specifically considers the use of robots and activities in hospital wards in Korea and also identifies concerns regarding privacy and malfunctions. However it has a number of gaps in terms of relationship aspects of care
Liang et al., (2019) Korea	Qualitative interviews	23 Paediatric Nurses	Qualitative Content Analysis	Comparable method and sample size but study of paediatric nurses and therefore can't be generalised to adult care
Liao et al., (2023) Taiwan	Quantitative Survey	358 Theatre nurses	Structural equation modelling technique	Identifies that benefits are more important than robot maintenance concerns However this is described as nurse robot engagement whereas it was actually intention to use
Nielsen et al., (2023) Germany	Focus groups	16 Nurses	Deductive content analysis	Focus group data combined with patient and relative interview data so unclear of nurse specific perspectives but findings demonstrating fear of issues relating to safety, increased workload
Turja et al., (2017) Finland	Correlative Questionnaire survey + analysis of Eurobarometer survey	3800 or 3900 Nurses & physicians (at least 1000 nurses)	Descriptive Statistical Analysis	Mixed nurses and therapists responses and the list of care related task is limited, Does include head nurses in the sample but combines with other managers so the views of nurse leaders cannot be known
Zrinyi et al., (2022) Hungary	Cross sectional factoral conjoint analysis	228 Nurses and student nurses (58.3% graduated)	Conjoint statistical analysis	Illustrates the relative importance that nurses give to care robots and illuminates the low priority with which self learning and robot autonomy is given. But 46% of sample were

Of the 15 studies selected, twelve used quantitative methods (generally a survey, e.g. Lee *et al.,* 2018; Turja *et al.,* 2018; Jang *et al*., 2021; Chang *et al*., 2021) and five used qualitative methods such as focus groups (Lee *et al*., 2020b; Nielson *et al*., 2022), or interviews (e.g. Laing *et al*., 2019; Ismail *et al.,* 2023). Two studies (Jin and Kim 2020; Lee *et al*., 2020b) used both qualitative and qualitative methods (mixed method).

3.12.2. Attitudes to robots

Seven of the included papers specifically looked at the attitudes or perceptions of nurses on the role of robots in nursing and the remaining eight included nurses in their population sample so that nursing opinions are captured. In the earliest study reviewed, Fuji *et al*., (2011) attempted to identify the tasks that robots could assist with and found that registered nurses were more likely to think robots could assist in general, than their care assistant colleagues. Turja *et al*., (2018) looked at nurses' (and other healthcare professionals) attitudes and Christoforou *et al*., (2020) directly explored attitudes in relation to specific robot design in a healthcare environment. Lee *et al*., (2018) looked at the degree of agreement that robots could contribute to nursing (a list of 40 nursing tasks) and Lee *et al*., (2020b) considered nurses' (and doctors') perceptions of how helpful bedside robots might be. Liang *et al.,* (2019) used semi-structured interviews to explore the views of 23 nurses about the use of robots with children. Ismail *et al*., (2023) also used interviews to explore the perceptions of ten ICU nurses.

The study by Turja *et al*., (2018) was the largest in terms of participant size as the study combined data from 2218 practical nurses, and a combined sample of 1782 nurses and physiotherapists (89% of whom were nurses). These samples were compared against the general Finnish population drawn from Eurobarometer data collected two years earlier in 2014. Eurobarometer polls ask EU citizens' views of subjects such as robotisation. Two variables were used by Turja *et al*., (2018) to identify the attitude towards robots: the general view of robots (GVR) and robot acceptance at work (RAW). They found that the healthcare professional group were slightly less positive than the general population but when asked about robots in care were slightly more positive. It is possible that the two-year time difference in data collection accounted for one of these variables and the list of 13 'care-related tasks' was not specific to nursing and did not include any correlation to the measuring and monitoring tasks explored by Lee *et al*., (2018). Therefore, whilst the study does not claim to be specific to nursing albeit published in a nursing journal and the professional background of the authors is unstated, it could be argued that there was a lost opportunity with such a large scale study.

Turja *et al*., (2018) did however identify differences in acceptance related to previous exposure to robots (either in the home or work setting) concluding that managerial experience led to greater experience with robots in healthcare which in turn led to greater acceptance. Whilst the study did not cross reference this to number of males with senior or managerial experience, they concluded that men were more accepting of robots.

Christoforou *et al*., (2020) also provided insight into healthcare professionals' expectations of robots which may have been linked to professional acceptance. The study found that 76% of their respondents expected a mobile robot to respond promptly to its tasks and 85%, for a robot to be available 24/7, respectively. This may be problematic in practice as currently robotic technologies are limited in terms of speed and the need for regular charging. Jang *et al., (*2021) also picked up the charging issue by including remote docking capability in their questionnaire. They also alluded to the need for speed – particularly around wifi enabled connectivity and data transfer which predictably were seen as important robotic functions for telemedicine robots.

Christoforou *et al*., (2020) undertook their survey of attitudes to robotic assistants as part of product design and testing of a healthcare robot. Although reporting that over 80% of the 115 respondents were nurses, the survey included university staff, nurses and nursing students in their definition of nurses. Notably this survey was conducted three years later than Turja *et al*., (2018) and the exposure to the test robots may partially account for the 89% of respondents who were said to be positive about the use of robotics in nursing. Closer scrutiny of the question asked revealed the actual question asked to be about the level of agreement with the statement *"I'm enthusiastic about adopting new technical applications if they enhance patient care"*. Such framing is arguably difficult to disagree with and doesn't specifically reference robots. This could explain the rather fewer 46% number of respondents appearing to welcome mobile robots into the healthcare environment. This study identified that 76% of respondents said they would feel confident in guiding colleagues to use robots which introduces the role of intermediary (although the questionnaire question appeared to relate to patients rather than colleagues). Interestingly this study reported that 27% of respondents' colleagues would reject the use of robots and was stated to be similar to the reported findings of Rebitschek and Wagner (2019) who found that a third of their German population would reject robots in nursing.

Autonomy may be a key factor in acceptance: A Hungarian study found that nurses and student nurses least preferred robots that understood free speech, looked human, behaved mechanically and self-learned, (Zrinyi *et al*., 2022).

Most of the studies investigated the perspectives of registered nurse but Ergin *et al.,* (2022) examined the perspectives of nurse managers which is particularly relevant for phase three of this study. Whilst a broad definition of manager (from ward manager to director) was used, this quantitative survey found that 55% of the 326 managers respondents thought that robots should not provide patient care (although 63% agreed that robots could provide predetermined patient care although this was not defined).

3.12.3. Perceived Occupational Threat

One possible reason for nurses rejecting robot provision of care may be the perceived occupational threat of robots to nursing, Christoforou *et al*., (2020) found that 35% of their participants believed this to be the case. Liang *et al*., (2019) also cited worries about their future employment if robots could undertake more of their nursing roles. Nurses also identified concerns about loss of clinical or communication skills developed through practice (Liang *et al.,* 2019). This correlates with 31.8% of nurses expressing concern about robots interrupting the rapport with patients (Lee *et al.,* 2018). However, despite these concerns nurses reported that robots could positively contribute to nursing care (Liang *et al*., 2019; Lee *et al*., 2018; Ergin *et al*., 2022). Similarly, even though Nielson et al (2020)'s study included a robot that could assist only, participants still raised the issue of potential substitution.

Despite the perceived occupational threat, Lee *et al*., (2020b) found that nurses identified a higher need for bedside robots than medical staff. Lee *et al*., (2018) identified several expectations of robotic use in terms of reduced workload, increased delegation of tasks and increased quality with 23.9% of their respondents expecting robots to decrease their physical activity. There was an expectation of delegation to robots with 18.2% of respondents agreeing that robots may enable them to concentrate more on nursing. Chang *et al*., (2021) found a positive correlation of these expectations with expectations of increased job satisfaction and health improvement, which in turn reduced intention to leave.

3.12.4. Disadvantages of Robots

A number of disadvantages of robots were identified, including physical limitations, safe operation in a crowded environment, interruption of rapport, device malfunction, and concerns about privacy.

Whilst Liang *et al*., (2019) was the only study that specifically captured nursing concerns around the physical limitations of robots, this was alluded to in other studies. Three studies used lists of potentially desirable robotic functionality which either currently exists or may be available in the near future (Christoforou *et al*., 2020; Lee *et al*., 2020b; Jang *et al.,* 2021). By suggesting these specific functions and excluding others they were implicitly suggesting limitations in capability. Sometimes the robotic limitation was more explicit as in the Christoforou *et al*., (2020) study which reported that a third of respondents agreed that robots working in crowded spaces could pose safety concerns. Similarly, the discussion about preferred shape and movement by Lee *et al*., (2020b) suggested safety concerns if bedside robots were free-standing, which was reiterated by Jang *et al*., (2021).

A further limitation relates to the communication capability of robots. Three studies (Lee *et al*., 2018; Liang *et al*., 2019; Ismail *et al*., 2023) cited nursing concerns about human-robot interaction, the interruption of rapport, the robotic inability to discern mood, feelings or meet individual care and development needs. Other studies included robot interaction capabilities within their suggested functionality lists for telemedicine and bedside robots (Lee *et al.,* 2020b; Jang *et al.,* 2021).

Five studies identified nursing concerns about robot malfunction (Fuji *et al*., 2011; Lee *et al*., 2018; Liang *et al.,* 2019; Lee *et al*., 2022), with nurses in the study by

Nielson *et al*., (2020) citing safety as the most important ethical concern in robotic development. Respondents in studies by Lee *et al*., (2020b) and Nielson *et al*., (2020) also identified concerns that use of robots might increase workload for healthcare professionals.

Four of the studies mentioned a lack of clarity around who was responsible for robotic deployment. Nielsen *et al*., (2020) and Jang *et al.,* (2021) referred to the need for clarity of liability-related regulations to govern responsibility for malfunction and both Liang *et al*., (2019) and Nielsen *et al*., (2020) identified nurses' concerns about the privacy issues in robotic handling of data. Ergin *et al.,* (2022) specifically explored this, finding that nurse managers were keen that robotic engineers and then hospitals should take responsibility for robotic malfunction which is similar to findings by Ito *et al., (*2015) that respondents would prefer hospitals to be responsible.

3.12.5. What is the role of a robot / what should robots do?

The studies covered a range of activities that participants were asked about robots performing. Table 3.8 identifies the activities explored by studies that correspond with elements of Fundamentals of Care and illustrates the variation in the activities which were explored by each study.

Jay-on Lee *et al*., (2018) gave the most comprehensive list of activities drawn from Park *et al.,* (2000) classification of nursing tasks. This rather reductionist breakdown of nursing into a list of tasks is nonetheless helpful in considering the specific tasks that a robot could undertake, enabling Lee *et al.,* (2018) to identify the top three desired roles for care robots as measuring /monitoring, mobility/activity and safety care.

Table 3.8. Activities explored by each study mapped to Fundamentals of Care elements.

Table: Fundamentals of Care activities explored in each paper																										
	Physical								Psychosocial								Relational									
First Author and Year	Rest and sleep	Personal cleansing and dressing	Medication Management	Toileting needs	Eating and drinking	Comfort	Safety	Mobility	Communication	Being Involved and informed	Respect	Education and information	Values & beliefs considered & respected	Dignity	Emotional Wellbeing	Privacy	Being empathetic	Helping patients to cope	Engaging with Patients	Supporting & involving families & carers	Working with patients to set goals	Active listening	Helping patients to stay calm	Being Compassionate	Being Present	Trust, Focus, Anticipate, know, evaluate
Chang (2020)																										
Christoforou (2020)							√																			
Ergin (2022)																										
Fuji (2011)		√	√		√			√																		
Ismail (2023)			√				√																			
Jang (2021)							√		√																	
Jin (2020)										√		√			√			√	√				√		√	
Lee, JY (2018)		√		√	√		√	√	√			√							√							
Lee H (2020b)						√	√		√			√			√											
Lee JH (2022)			√			√	√	√							√			√								√
Liang (2019)			√							√		√			√					√			√		√	
Liao (2023)																										
Nielsen (2022)														√		√									√	
Turja (2017)			√				√	√	√			√														
Zrinyi (2022)							√		√																	

Fuij *et al*., (2011) similarly constructed a questionnaire of physical tasks such as 'cleaning and bathing, mobility assistance and dressing assistance'. Perhaps unsurprisingly given this study is over a decade old, more than 70% were not clear of what a humanoid robot could do (Fuji *et al*., 2011). Hyeongsuk Lee *et al*., (2020b) study found that both survey respondents and focus group participants also identified monitoring patient safety as the most helpful function for a bedside robot. The survey design in this study included only functions that a bedside robot might be able to perform and excluded personal care functions such as assisting with mobility or hygiene needs.

Liang *et al*., (2019) explored robotic use through the perceptions of 23 nurses and identified advantages such as reducing workload by taking on repetitive or routine tasks such as orientating patients to the environment or giving routine information and instruction to children or their family caregivers. A data processing role in finding, collating and interpreting results was also conceived and respondents also suggested a role in reminding nurses of specific tasks. Importantly Liang *et al.,* (2019) included the roles of therapeutic play and immediate companionships, describing nurses' accounts of the advantages such as less fear and more comfort from robots. The participant quotes give important insight here with each of them referring to a substitution for nursing time:

> "*I don't have enough time to be with them",*
>
> *"robots can help us be there when we are* busy*"* and
>
> *"they* [robots] *can comfort the children before I come*".

The differentiation of tasks that a robot should undertake was a recurring theme across the literature and was differentiated by different authors into professional or clinical and non-professional or non-clinical tasks (Christoforou *et al.,* 2020; Chang *et al*., 2021) and as nursing tasks and non-value-adding nursing activities by Lee *et al.,* (2018).

Conclusions cannot be drawn across all the studies as three of the studies considered very specific robotic applications which limited the activities of functions considered (Christoforou *et al.,* 2020., Lee *et al*., 2020b, Jang *et al*., 2021).

However, the activities considered could be divided into the following broad categories which are discussed below:

- giving information,
- companionship,
- lifting,
- fetching and carrying,
- assisting with patient mobility,
- monitoring and measuring vital signs,
- calling nurses and summoning help,

- risk management & safety care, and
- medication management.

Liang *et al*., (2019) used qualitative interviews with paediatric nurses who identified information giving as a key area that robots could assist with. Liang *et al*., (2019) also picked up the potential of a robot being able to communicate in different languages, a feature that Turja *et al.,* (2020) also discussed. Lee *et al*., (2020b) noted the low priority given to robots having communication capability and this perhaps reflects the broad scope of communication in that both Liang *et al.,* (2019) and Lee *et al*., (2020b) referred to bounded information which could be predetermined, e.g. medication information and repeating routine clinical information such as test results. In contrast, Lee *et al*., (2018) referred to communication with patients and delineated this from counselling and education.

Three studies considered children's needs in hospitals and found support for robots acting as companions, with respondents advocating a role for robots in providing comfort and emotional support, education and therapeutic play, (Liang *et al*., 2019, Lee *et al*., 2020b, Jin and Kim 2020). This corresponds with a wider body of research in the care home and homecare sector (Broadbent, Stafford and MacDonald, 2009) where companion robots were documented to assist with agitation and another paper about the use of a robotic pet in a hospital (Hung *et al*., 2021). Liang *et al.,* (2019) built on this, suggesting that robots could provide a buffer between the nurse and the child whereas Jin and Kim (2020) recommended capitalising on the novelty aspect of robots. Interestingly, whilst Fuji *et al.,* (2011) focused on physical aspects of care, one of the main reasons cited that robots could not perform procedures was that humanoids lacked the warmth of human care suggesting that social interaction capability was key to robotic acceptance.

Turja *et al*., (2020) suggested nursing acceptance of robot help in ergonomically challenging tasks such as lifting heavy objects and reaching high shelving. This concurs with the findings in Chang *et al*., (2021) study of nurses' needs within the operating theatre complex where the use of robots to lift heavy instrumentation was positively linked with perceptions of health improvement for nurses. Liang *et al*., (2021) and Lee *et al.,* (2018) also found support amongst nurses for robotic fetching and carrying functionality. However, Turja *et al.,* (2020) commented that there was no difference between respondents' acceptance of robotic transport of materials or equipment and moving patients. Whilst that might have been the viewpoint of Turja's respondents, the wording of 'moving a patient' is ambiguous and could have referred to helping to change a patient's position in bed or to pushing a patient's wheelchair from A to B. It is notable that respondents indicated significantly less agreement with a roboticised autonomous stretcher. This corresponds with the earlier study by Fuji *et al*., (2011), where there was significant support for robotic assistance with moving a stretcher but very little support for this being autonomous.

Nurses were also concerned about robots adding time or causing injury, as in the study by Nielsen *et al*., (2020) which considered a specific robot arm to assist with moving and positioning bed-bound patients. However, positive aspects such as enabling a nurse to undertake tasks in a more timely manner rather than await a colleague were also identified.

Nurses identified robotic assistance with patient mobility and activity tasks, as one of the top three activities that a robot could help with (Lee *et al*., 2018). Similarly, Christoforou *et al*., (2020) reported that two-thirds of the respondents (including nurses) thought that robots may save nursing time and 83.5% thought that robots would reduce the physical burden of daily care. This corresponds to, rather than contradicts, nursing acceptance of robotic help in ergonomically challenging situations (Turja *et al*., 2020).

Most of the papers selected referred to a robotic role in measuring and monitoring patients' vital signs with Jang *et al*., (2021) referring to the robotic measurement of HR, oxygen saturation and blood pressure, Lee *et al*., (2020b) referring to 'taking vital signs' and Lee *et al*., (2018) finding measuring and monitoring to be the function most supported by nurses. It is clear then that nurses could see a role for patient monitoring by robots. It was less clear whether nurses would support the process of taking or setting up the measurement i.e. would nurses support robots autonomously approaching a patient and wrapping a blood pressure cuff around a patient's arm? Lee *et al*., (2020b) included the functionality of robots sending emergency alerts and calling for nursing help, but it was not clear if this was an algorithmic capability or audio/visual capability.

Whilst Turja *et al*., (2018) principally explored attitudes, their questionnaire asked about level of comfort with a robot assisting in a care work-related task. Interestingly none of the 13 items referenced monitoring although two telepresence items (telepresence in emergency situations and in health checks) were included both of which could have been construed as monitoring functions albeit with a human operator. The study established that "*generally speaking nurses have a positive view of robots"* but despite its impressive sample size this study was limited by its cursory approach to robotic tasks or activities so conclusions could not be drawn.

Jang *et al.,* (2021) adapted the questionnaire by Lee *et al*., (2019) and focused on telemedicine functions. They found that in addition to vital signs monitoring, being able to avoid obstacles and transmit a patient examination report were the most desired robotic functions (Jang *et al*., 2021). Given this study focused on telemedicine, robotic autonomy was not considered although was mentioned in relation to navigation. Interestingly respondents valued non-verbal signals such as facial expression recognition equally to temperature monitoring, but this was omitted from the ranking of functional needs table. Indeed, this study conflated a number of robotic functions such as blood pressure monitoring function with robotic features such as video and image display and it was clear that the options were limited to those that might be provided shortly thus limiting the long-term currency of the research. The study did not mention teleoperation, but ease of use was noted to be an important aspect of robotic design as was the ability to disinfect and cleanse the robot which was prioritised by both doctor and nurse participants.

Two of the studies included fall detection and fall injury prevention which were seen as helpful functionalities for robotics. Again, it wasn't clear if the falls and injury prevention functionality included physical assessment, but Korean nurses identified 'safety care' as one of the three primary roles for robots (Lee *et al*., 2018).

Nurses also identified a role in medication preparation and calculation and cannulation was also suggested (Liang *et al*., 2021). Medication support was also one of the areas cited in Fuji *et al*., (2011) study but results were not reported on this aspect suggesting that in 2011 this was not conceived as something a robot could assist with.

In summary, these studies indicate a rising acceptance that robots may have a role to play in nursing practice. Robots are most likely to be accepted in tasks related to fetching and carrying equipment and materials, recording and monitoring patient's vital signs and falls risk, and in assisting with social companionship through access to online games and services.

3.13. Impact on Nursing

Whilst studies picked up concerns about the impact of robots on job security, the impact of robotic assistance on job content was less well explored although Fuji *et al*., (2011) reported setting out to do this, but found that participant knowledge of robotic capability hampered their study. Christoforou *et al.,* (2020) suggested a new nursing specialism of managing a fleet of robots and Chang *et al*., (2021) argued that robots would enable nurses to better focus on professional nursing tasks. The qualitative methodology of the Liang *et al*., (2019) study gave voice to nurses identifying that their role might change as a result of robotic involvement. Exhorting nurses not to blindly depend on robots, Liang *et al*., (2019) suggested a greater need for nurses' critical thinking and reflection skills in order to decide how robots can be used. It is this critical thinking that Zrinyi *et al*., (2022) suggested was behind nurses' preference for robots that follow commands and act as trustworthy machines rather than robots that would self- learn and respond to free speech. Furthermore, they proposed that this was driven by a fear of artificial intelligence out-performing human nursing ability, challenging the core values of nursing (Zrinyi *et al*., 2022).

3.14. Gaps in research

Whilst there was a significant amount of literature about the use of robots in care, including literature reviews, much of this literature refers to home and care home contexts, with few studies considering the hospital context. When considering studies within the hospital context – most referred to the use of medical robotics in the form of surgical robots such as the Da Vinci Robot used in keyhole surgery.

When narrowing the search of relevant research to hospital nursing (and excluding peri-operative nursing) there were only fifteen studies and none of the studies explicitly explored UK nurses' perceptions. All but one of these studies were published in the last four years which illustrated that this was still an emerging area of research, albeit that most of the studies limited their questionnaire elements to current technological capability.

Four of the studies had particular relevance: The study by Liang *et al*., (2019) as a qualitative approach explored some of the roles, difficulties and opportunities afforded by robots in nursing. Ismail *et al*., (2023) also found that nurses saw opportunities in robot use in terms of saving energy and time and enhancing safety. This small sparsely reported study had a sample of 6 male participants out of a sample of ten which was unusual for nursing, however they charted drawbacks in terms of reduced interaction, patient perception and nursing skill levels to operate the robots which correspond with other studies. Lee *et al.,* (2018) study attempted to identify the range of nursing tasks robots could assist with from a sample size of more than 300 RN participants. This Korean study provided a helpful baseline from a country expected to be super-aged by 2030 which suggests a strong incentive for assistive technologies. Similarly, the work by Ergin *et al*., (2022) had particular relevance, due to the nurse manager participants who might lead robot adoption.

In summary, existing studies did not explore how robots might be used to maintain the essence of nursing as defined by the FOC or how to make optimal use of the possibilities of robot technology. None of the studies specifically looked at roles robots may play in the delivery of nursing care in the UK and only two studies considered a constructionist approach to the topic where initial views and perspectives might have been moulded, amended or embedded through discussion with others. None of the studies explicitly considered future deployment which was a gap given the future workforce challenge. Furthermore, very few focused on hospital nursing. This could only be done by bringing together the perspectives of roboticists, nurses and senior nurses as in this study with an explicit future focus.

Further research was required to define tasks and activities that robots might undertake and identify the advantages and barriers to the introduction of robots in order for nursing to consider how it may need to prepare and adapt if required. This then provided an opportunity for this study to explore the topic further. Specifically, the following gaps in the literature were identified:

- No study in the UK considered future requirements for robots in nursing and therefore these perspectives of UK nurses were largely unknown;
- No study specifically explored strategic nurse leaders' perspectives of robots in nursing despite Turja *et al.,*(2018) recommending that future studies should study healthcare professionals as a distinct robot user group and consider different levels of staff.
- Current studies tended to consider either tasks or attitudes and therefore the roles that a robot might undertake within the nursing workforce had not been explored.

This suggested the need for further research to close this gap, particularly if robots were to be considered part of the future solution.

3.15. Summary of Chapter

In conclusion the literature review identified fifteen studies which specifically looked at nurses' perspectives on the role of robots in hospital nursing. These studies considered the tasks or activities that robots may undertake and explored how assistive technologies might be accepted by nurses in practice. Primarily these studies were more focused on physical assistance, while psychosocial and relationship activities were not explored in a hospital setting. Several gaps in the literature were identified suggesting the need for research orientated to the future which considers the perspectives of UK nurses at different levels.

Chapter 4: Methodology

4.1. Introduction to chapter

Having considered the context of future workforce challenges in nursing and the rapid progress of technological development, the literature related to robotic technology in health and social care was outlined and the specific literature related to nursing perspectives reviewed in detail. This pointed to a gap in the research both theoretically, as none of the studies explicitly considered perspectives on the future, but also methodologically as most of the studies were quantitative in nature and as such could not detail the rationale for the range of responses. Furthermore, the four studies that employed qualitative methodologies were either related to a specific robot usage or to children's nursing. In this chapter, firstly, I describe the aims of this study to address these gaps and the consequent research question. Secondly, I explore the theoretical foundations and research paradigm that underpin the study, including a description of my theoretical standpoint. Thirdly, I discuss the choice of methodological approach, concluding that a social constructionist approach within the social constructivist paradigm best fits my exploration of this topic.

4.2. Future Forming research

The potential role of robots in nursing care in UK hospitals has not been extensively researched. This study aimed to actively shape the future by exploring the perspectives of front-line nurses and strategic nurse leaders (Chief Nurses and Thought Leaders) in order to understand how they perceived the use of robots in future nursing. In addition, the views of roboticists were also explored. Gergen (2015) discussed future-forming research as a way of shaping the future and this study intended to stimulate informed debate by exploring opinions on the future delivery of therapeutic nursing care and to provide recommendations for a nursing led response.

4.3. Research Aim, Objectives, and Research Question.

The ***aim*** of this study was to discover ***how robots could support the role of nurses in the future.*** Whilst this was not limited to hospital nursing, the inclusion of only hospital Registered Nurses meant that the findings will be predominantly hospital focused.

In order to achieve this aim, the research objectives were as follows:

- to explore robot developer's views of the likely capability of robots in the next 10-15 years in nursing
- To explore and analyse nurses' perspectives on what might be acceptable and appropriate roles and activities for robots in hospital nursing.
- To identify the factors that might support or be a barrier to robot use in the future delivery of nursing care
- To propose how robots might contribute to the delivery of hospital nursing and make recommendations for the next steps.

The ***research question*** was as follows: ***"What is the future role of robots in hospital nursing* in the next 10-15 years? *A qualitative study of roboticists and nurses' perspectives"***

4.4. Personal reflections on informal conversations

During the early stages of discussing robots in nursing with nurses, executives, and friends, their opinions influenced the choice of paradigm, method, and methodology. Conversations typically began with surprise and interest in the subject, followed by individuals expressing their beliefs about what robots could or should do. This suggested a relativist ontology and a subjective, context-dependent nature of the topic. Interestingly, these opinions evolved throughout the conversation. People began to inquire about robot capabilities and made several declarations regarding principles, such as "*so long as x or y happens, then z would be okay*." These early informal conversations suggested several insights:

The topic is still emerging, leaving individuals with little personal experience or knowledge to reference. Initially, opinions and perceptions were influenced by media representation and current technology, some of which was outdated. During conversations, opinions were consciously formed and explored. However, despite this, individuals tended to hold onto fixed beliefs as the discussions progressed. Additionally, in informal conversations, the role of the 'researcher' was more akin to that of a friend or colleague, making it difficult to simply observe. This was especially true when robotic capabilities were exaggerated.

Initially, the conversations were rooted in the present and based on current assumptions of fully autonomous human replacement robots that were clearly different from the literature. By remaining silent I risked allowing the conversations to continue to be based upon misguided notions which could lead to unrealistic viewpoints. This exemplified the need for me as a researcher to take a participative role contributing expertise on robotic capability. These insights informed the research design and pointed to the underlying philosophical basis of this research.

4.5. Theoretical basis for the study

It is widely agreed upon that researchers must clearly establish the theoretical foundations of their research for the benefit of the research, their readers and themselves. The concept of a paradigm which brings together a set of constructs or beliefs is based on work by Kuhn and cited by scholars (Munhall, 2001; Holloway, 2008; Parahoo, 2014; Corry, Porter and McKenna, 2019). Different accounts of paradigm constructs appear in the literature with Creswell (2003) and Kelly, Dowling and Miller, (2018) limiting a paradigm to an epistemological stance, and including ontology with epistemology and methodology. Chilisa and Kawulich, (2012) also included axiology (ethics and value systems). For this study, I used the definition of a paradigm as a framework of beliefs about reality (ontology), the nature of knowledge (epistemology), methodology, and axiology (values) in which the research is situated.

There is also diversity in the types of paradigms described by different authors, e.g., Lincoln, Lynham, and Guba, (2011) explored six paradigms - positivism, post-positivism, constructivism, interpretivism, feminism, and critical theory. In contrast, Creswell (2014) suggested four paradigms - post-positivism, participatory/advocacy, social constructivism, and pragmatism. Given that paradigms are conceptual frameworks this is not surprising, and perhaps enables a more nuanced consideration i.e. social constructivism rather than the wider constructivism paradigm.

4.5.1. Is the paradigm related to the research or the researcher?

Authors offered opposing views on whether a paradigm's theoretical position relates to the researcher or the research. Borbasi, Jackson and Wilkes, (2005) suggested that the theoretical position belonged to the researcher who designed the research. Chilisa and Kawulich, (2012) went as far as proposing that researchers choose their own paradigmatic view based on their personal beliefs and value systems. Accepting that the researcher's theoretical position shapes their thought process and beliefs, it follows that these ultimately influence their choice of methodology and methods (Borbasi, Jackson, and Wilkes, 2005). Others such as Weaver and Olson, (2006) argued that it is the research itself and its purpose in conjunction with knowledge development, that should guide paradigm selection. This seemed important as it is entirely possible that the researcher's preferred paradigm doesn't fit with the research. For this reason, the decision on this study was primarily based on the research question, and for transparency, the rationale is outlined below.

4.5.2. Researcher's personal beliefs

Transparency of the researcher's personal beliefs and influences is crucial for research credibility and quality (Tracy, 2010; Maguire, 2019). In this study, I was influenced by extensive reading within the critical realism paradigm and my ontological beliefs most closely align with Bhaskar's (2008) stratified reality. This means that I accept that there may be an external reality awaiting discovery for some aspects of the world such as geology and human anatomy. Consequently, for natural world phenomena, I am comfortable aligning with a realist viewpoint. However, I regard these assertions as too narrow for the social world of human behaviour where matters of conjecture and opinion intrude. In the social world, I thought it unlikely that there is a single, agreed viewpoint awaiting discovery and instead consider that multiple perspectives of reality will exist. Therefore, the realist approach appeared inadequate and incomplete and reinforced the need to look beyond my personal beliefs to the nature of the research itself.

4.5.3. The paradigmatic basis for the research

This study explored the future for robots to assist in therapeutic nursing care. This involved considering a world that does not yet exist, therefore objective study was not possible. This research was therefore subjective and captured perceptions and perspectives on what might be. This results in multiple perceptions of a future reality, confirming the appropriateness of a relativist ontology. Through initial conversations, I observed that people developed their opinions through discussion with others, indicating a constructive nature to views and opinions (Holloway, 2008).

As the researcher's interpretation also plays a role in the results, positivist and post-positivist paradigms were rejected, and consideration was given to interpretivist and constructivist paradigms.

4.5.4. Research Paradigms: Interpretivist or constructivist?

Interpretivist and constructivist paradigms emerged as a response to positivism, with both emphasising the importance of subjective experience, perception, and language. While they share some similarities, they differ in their epistemological approaches. Parahoo, (2014) noted that constructivists are essentially interpretivists who acknowledge the existence of multiple realities.

Interaction is key to both constructivist and interpretive paradigms (Schwandt, 1998). The interpretivist researcher uses interactions to gather data on the experiences of individuals and the reasoning behind them (Kelly, Dowling and Miller, 2018), while the constructivist researcher focuses on analysing the interaction itself and how it contributes to the construction of knowledge (Schwandt, 1998). In essence, the constructivist paradigm prioritises the way knowledge is constructed rather than interpreted. For this study, the intent was to use interaction with participants and group interactions to gather insights and perspectives that may not have been previously conceived. This aligned with the constructivist paradigm's philosophical view of relativism and subjective viewpoints, as well as its methodology, which involves participants considering, developing, and refining their insights through interaction with others. This approach was also consistent with qualitative research, in which meaning can be socially constructed and explored (Crotty, 1996). As a result, the constructivist paradigm was confirmed as the most appropriate framework for this study. The ontological, epistemological, and axiological assumptions that underlie this paradigm will now be discussed.

4.5.5. Constructivist Paradigm

Ontology is a term used to describe the nature of beliefs regarding reality (Richards, 2003). However, there is some debate surrounding whether constructivist approaches have an underlying ontology. While three published constructionists (von Glasersfeld, 1991; Gergen and Gergen, 2003) argued that their focus is epistemological, relating to the construction of knowledge. Schwandt, (1998) described their perspective as idealist and relativist, both of which are ontological perspectives. Additionally, Sismondo, (1993) supported the idea that constructivist approaches take an ontological stance, drawing from Berger and Luckmann's, (1966) argument that reality is socially constructed. Guba and Lincoln (1989) also asserted that the constructivist paradigm is idealist, suggesting that what is real is constructed in the minds of individuals. This further supported the idea of a pluralist and relativist reality, indicating a relativist ontology which was appropriate for this future-focused study.

According to Schwandt (1998), constructivist theories can be categorised into different levels of epistemology. Parahoo (2014) suggested physical constructivism, social constructivism, and radical constructivism. Von Glasersfeld (1991) is perhaps best known for his work on radical constructivism, which focused on understanding the nature of knowledge and the process of acquiring it. On the other hand, Kenneth and Mary Gergen, (1991) are credited with social constructivism, which emphasised the role of social interaction in the creation of meaning. The focus of this study was on knowledge created by discussions and interactions between participants which most closely aligned with a social constructivism paradigm.

4.5.6. Ontology and Epistemology of Social Constructionism

In the realm of social construction, there were multiple viewpoints, which suggested a relativist ontology. Ontologically social construction like its broader constructivist origins, leans towards multiple constructions and therefore its ontology might reasonably be considered relativist (Guba and Lincoln, 1994; Cottone, 2017). Smith, (2010) distinguished between "weak" and "strong" social construction, with the former requiring maintenance to sustain the constructive aspects of reality. On the other hand, Gergen (2009) whilst arguing that social construction holds no ontological claims, also argued that for ‘strong’ social construction where reality is constituted through language and socially constructed. This suggests a fusion of ontology and epistemology which Guba, (1990) supports. In these respects, it is difficult to delineate between ontology and epistemology as beliefs about reality and knowledge both rest within conversations and interactions. In this study, a relativist ontology of weak social construction was accepted, as it was likely that meaning would continue to evolve through discussion and consideration (Reason, 1994).

The subjectivist epistemology was less in dispute (Appleton and King, 2002; Lee, 2012). Knowledge in this context, was represented as a human product that is socially and culturally constructed (Gredler, 1997; Ernest, 1998).

4.5.7. Axiology

After selecting social constructivism as the appropriate paradigm, axiology became crucial as perspectives on what is valued in nursing and patient care would likel influence how results were reported and interpreted (Braun and Clarke, 2021b).   It was important to recognise that all social inquiry was both value-bound (influenced by values) and value-laden (Nagel, 1961) to some extent. Chilisa and Kawulich, (2012) suggesed that constructive researchers disclose any values and biases that may affect the study's neutrality. For this study, it was accepted that a neutral position was not possible and this was further explored through reflexivity. Reflexivity was defined by Whitaker and Atkinson, (2019) as the practice of being mindful of how thinking is shaped by pre-existing knowledge and how research claims are made, and is discussed further in the following chapter.

4.6. Research Approach

Having identified the most relevant paradigm, the next step was to consider the approach or study design that would best fit the research question and be consistent with the social constructionist paradigm. The two main options: quantitative and qualitative (or mixed method) were both considered in the context of the study goals of future-forming research, as outlined by Gergen, (2015). This meant that two guiding principles were taken into consideration: the results had to be meaningful enough to impact the future, and the research had to have practical use. While generalisable results from a quantitative study may be appealing (Muijs, 2010), the available literature used predominantly quantitative methods and was not able to fully capture the range of opinions, reasons, and rationales that might exist. Understanding this range of perspectives is important for the future adoption of robotics, as all perspectives need to be addressed, not just the most common ones. Therefore, I decided to use a qualitative design, as it is better suited to capturing a plurality of perspectives. The quantitative approach was ultimately rejected.

A number of options were considered for the design approach for the study including a critical realist approach, critical theory, ethnographic, action research, grounded theory and phenomenological approach which are discussed briefly in the following paragraphs.

Although the critical realist approach, which focuses on the relationship between context, mechanism, and outcome, held promise in discovering what works in different circumstances, it is firmly rooted in a realist paradigm (Marchal, Kegels and Van Belle, 2018). While Bhaskar, (2008) argued that critical realism is more an epistemological stance than an ontological underpinning, the components of cause and effect cannot be determined in advance and therefore did not align with this research.

The three-stage process in critical theory shares similarities with critical realism, as noted by Cohen, Manion and Morrison, (2018) in their exploration of political perspectives. While this approach could have been relevant to policy discussions on robots in nursing, the emancipatory elements of critical theory leant towards action research, which did not fit with a study of future implications.

The co-participant approach of ethnographic approaches appealed because it enables the researcher to contribute their unique knowledge, skills, and attributes to the study (Borbasi, Jackson and Wilkes, 2005). However, since the focus was on exploring the future potential of robots, observing the current environment was not appropriate and thus excluded from the study.

The use of an action research methodology was also considered, particularly as a key principle of action research is that it is both socially meaningful and socially responsible which resonated with this study (Levin and Greenwood, 2011). On the other hand, robots are not well enough developed (yet) to play a role in nursing care and Weaver and Olson, (2006) argued that participatory action research is inappropriate if the opportunity to engage in action is not included. Therefore, such an approach was considered to be premature.

A grounded theory (GT) approach was also explored as a way to contribute to theory development which could inform strategic decision-making (Parahoo, 2009). Although there are already theories of technology adoption which I will refer to later in this thesis, I did not consider there to be sufficient data to generate further theory at this point.

Phenomenology was also examined due to the emphasis on describing phenomena and human experiences (Holloway, 2008; Paley, 2017). However, it was recognised that the phenomenological focus on lived experience was not entirely congruent with new awareness and this method was discounted.

Although each of the approaches above has strengths, it is important for the methodology to support knowledge development in the future. In addition to the paradigmatic elements of constructivism, Denzin and Lincoln (1994) suggested that constructivism also constitutes a methodological approach because it seeks to comprehend and reconstruct, extending beyond philosophical foundations to encompass understanding and reconstruction. This aligned with the study's goal of shaping the future and with the views of the prominent social constructionist Gergen who called for action in future-oriented research (Gergen, 2015). Therefore, in summary, having explored a number of approaches which did not fit well, it was clear that a qualitative constructivist approach was best suited to this study.

4.6.1. Terminology: Social constructionism and social constructivism

Authors often used the terms social constructionism and social constructivism interchangeably and the terms differed from author to author (Sismondo, 1993). Galbin, (2014) used the same definition for both social constructionism and social constructivism on page 82 whereas others differentiated: Holloway (2008) and Schwandt, (1998) defined Constructio**nism** (after Gergen, 2009) as a focus on the content of social interaction, and Constructi**vism** (after von Glasersfeld, 1991) which focuses on individual perspectives (which have been formed through interaction). For preciseness, this research used the terminology of the social constructionist approach because the knowledge was formed from the content and perspectives arising from the collective interactions, rather than extracting the individual perspectives that follow any interaction. This social constructionist approach was underpinned by a constructivist paradigm and a constructionist approach to the method was the principal methodology for new knowledge creation.

4.6.2. Challenges of Social Constructionism

There are two principal critiques of social constructionism as an approach, firstly constructivism has been criticised for its focus on individual views whilst ignoring the impact on society and a radical relativism stance (Appleton and King, 2002). Pawson and Tilley, (1997) similarly argued that social construction cannot explain social reality in complex situations, illustrating their critical realist need to uncover or discover the causal reality.

The second critique, in contrast, suggested that social constructionism took an overly narrow focus on society and culture as a causal factor in human behaviour, (Slingerland, 2008; Pinker, 2016). Sokal and Bricmont, (1999) also argued that the role of biology and physical sciences is ignored or irrelevant to understanding human behaviour. These criticisms were acknowledged, however, this study was not focused on finding causes of behaviour but rather on forming insights that can shape the future through further debate and perhaps policy formation.

4.6.3. Role of the researcher.

The role of the researcher in social constructionism is to detail the multiple realities that emerge including the expression of ideas, helped by the researcher. Appleton and King, (2002) argued that this must include divergent or conflicting constructions of reality in order to be considered trustworthy. Guba and Lincoln, (1989) argued that the observer (or researcher) is part of the construction and this fitted with the exploration of a new topic area where as the researcher I had developed a greater understanding of current literature and needed to prompt and suggest robot capability in order that participants could consider future possibilities. Herein lies one of the criticisms of social construction, in that the role of the researcher as the participant could be considered also to be introducing bias (Schwandt, 1998). Whilst this 'bias' was acknowledged by Braun and Clarke, (2021b) they argued that researcher subjectivity is an asset to research providing it is accompanied by reflexivity.

4.7. Chapter Summary

This chapter outlined the theoretical underpinnings to the study and situated it within the constructivist paradigm using a constructionist approach to the methods. This constructionist approach provided the theoretical underpinnings to the discussion of methods for data collection and analysis in the following chapter.

Chapter 5: Methods of Data Collection and Analysis

5.1. Introduction to Methods Chapter

This chapter considers the methods used to capture the data by outlining the study design and the rationale for a three-phased sequential design, and then the methods of data collection and analysis for each of the three phases. The chapter also considers the quality criteria for this study and how these were addressed together with the ethical considerations.

The Chapter structure is as follows: Overall study design is outlined in section 5.2. Section 5.3. then explores methods for data collection and analysis for phase 1 of the study (Online Roboticist Interviews). Section 5.4 then considers data collection for Phases 2 and 3 which both used focus group method. Section 5.5 then details the population, sample and recruitment for Phase 2 (RNs) followed by section 5.6 which describes the population, sample and recruitment for Phase 3 (Nurse Leaders). Section 5.7 gives a short reflection on the success of online methods followed by Section 5.8 which discusses the thematic analysis process for both phases 2 and 3.

5.2. Study Design

5.2.1. COVID-19 Redesign

The study took place during the COVID-19 pandemic which in March 2020 paused all NHS research activity, except that related to COVID-19. Face-to-face meeting activity was prohibited, and the study needed redesign in order to progress. Prior to COVID-19, studies identified disadvantages of online methods including access to a device or computer and software; reluctance to be recorded (particularly video recorded); information security and potential loss of spontaneity within a group context (Tuttas, 2015a). However, the acceleration of technology adoption during COVID-19 (Sorrentino, 2021; Dowding *et al.,* 2023), increased the usage of conferencing platforms such as Microsoft Teams, Google Meet and Zoom as an alternative to face-to-face meetings. This study which planned telephone interviews and face-to-face focus groups, was therefore redesigned in April 2020 and sought to take advantage of the conferencing software and utilise online methods of data collection.

5.2.2. Selection of Online Conferencing Platform

Given the redesign of the study to online methods, a set of criteria was required to choose the appropriate conferencing platform and perhaps more importantly to deselect any that might be inappropriate. Tuttas, (2015a) suggests such a set of criteria, and these were adapted for this study and are detailed in Table 5.1. Zoom was selected as it met all the criteria and was supported by the university, thus making data storage easier. Zoom was used for all phases of the study and worked well.

Table 5.1. The criteria for the choice of conferencing platform

Table: Criteria for choosing a suitable digital conferencing platform for Interview and Focus groups
1. Compliance with Oxford Brookes University Guidance 2. Platform must support up to 12 participants visible in grid or gallery view 3. Platform must support real-time audio and full-motion video imaging 4. Platform must be secure and conference must only be accessible to invited parties (i.e. consenting participants and research team) 5. Platform must advise all participants when recording is live 6. Both audio and webcam images must play back both audio and webcam images from saved recordings in grid or gallery view. 7. Captions and transcription must be possible 8. Participants must not be required to install additional software 9. Platform must be device agnostic and usable on both home and work devices 10. Platform must include a chat facility and be easy to use 11. Full deletion of recordings must be possible once transcription and review is complete

5.2.3. Multi-level study design

This study comprised a multi-level sequential design (Kreuger and Casey, 2015) with three phases of data collection, with participants drawn from three discrete populations each with a different level of experience: Robotic Developers (Roboticists); Registered Nurses (RN) and Chief Nurses/National Nurse Leaders. Analysis of data from each phase of data collection (interviews or focus groups) was presented to the next phase of participants providing an iterative analysis (Srivastava and Hopwood, 2009) as the study progressed. This is presented schematically in Figure 5.1 with the overview of each Phase presented in Table 5.2.

Figure 5.1. Schematic view of the multi-level sequential nature of the study.

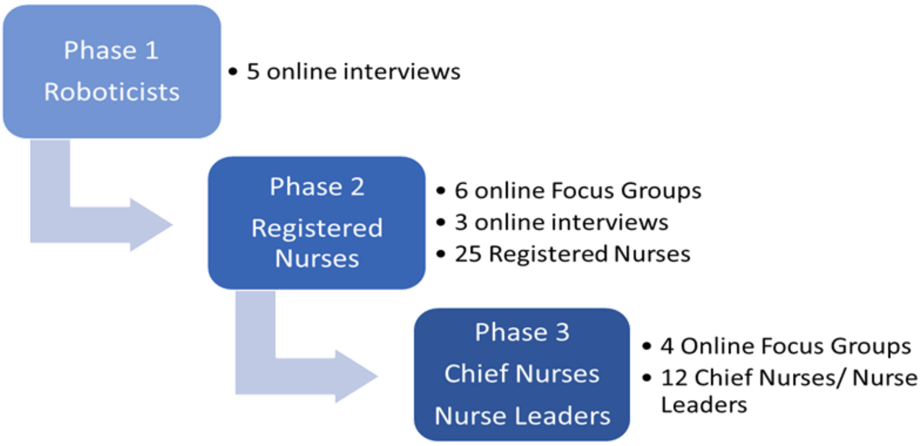


Table 5.2. Summary overview of the three phases

Table: Summary of population, sample, aims, methods and sample size				
Phase	**Population**	**Aim**	**Method**	**Sample**
1	Roboticists	To identify the likely range of developments in robotic technologies in the next 10-15 years	Internet interviews with audio-visual recording	5 individuals
2	Registered Nurses Band 5 & 6	To identify the role that robots could /should have in the future delivery of nursing care	Online Synchronous Focus Groups with audio-visual recording	25 Registered Nurses: 6 Focus Groups of 2-6 participants plus 3 interviews
3	Chief Nurses & National Nurse leaders	To identify the role that robots should have in the future delivery of nursing care	Online Synchronous Focus Groups with audio-visual recording	12 Chief Nurses/Nurse Leaders in 4 Focus Groups of 2-5 participants

5.2.4. Rationale for Three Phases

As the topic was new to most, the initial phase of the study sought to establish a baseline understanding of likely robot capabilities in the next 10-15 years. This prevented over or underestimation of robot capabilities, which could have hindered the research's practicality.

Phases two and three focused on gathering perspectives from two distinct nursing populations: nurses who directly provided patient care and executive nurse leaders responsible for strategic planning and decision-making regarding the future of nursing.

Phase Four was designed as a final phase of face-to-face focus groups. Given that the study was exploring technology acceptance, it was important not to exclude any potential nurse participants who might want to be involved but were hesitant about the online nature of data collection. Every participant was offered the choice of on-line or face-to-face with separate consent forms and explanations provided. Two people expressed an interest in the face-to-face option, but one withdrew due to imminent maternity leave and the remaining person suggested completing a recorded telephone interview instead of the video conference. Therefore, the fourth phase was not required as no remaining participants opted into this phase.

5.2.5. Rationale for Iterative Design

The three-phase approach created the opportunity to employ an iterative design by using the learning from the first phase to inform subsequent phases (Srivastava and Hopwood, 2009). This enabled RNs to understand the likely capability proposed by Roboticists. It also enabled nurse leaders in phase 3 to comment on and take account of RN perspectives when considering the next steps for nursing. Such iteration generates 'more useful, rich qualitative data' (Le, Lanthorn and Huang, 2019) and therefore the study was designed to facilitate this.

5.2.6. Decision making regarding participant populations

Narrowing a study to a meaningful population is an important aspect of doctoral study (Grover, 2007). The ability to estimate future robot capability was important for the roboticist participants and therefore knowledgeable robot developers were identified as the target population. The RN population sample was initially limited to newly qualified registered nurses at Band 5, and later amended to include team leaders at Band 6. Whilst acknowledging that staff in support roles such as nursing associates, healthcare assistants, nursing auxiliaries and nursing assistants undertake much of nursing care delivery, RNs were considered the most appropriate participants for Phase 2. This was because RNs are the critical decision-makers regarding nursing care and all support roles (should) work under their supervision.

A further consideration was the need for heterogeneity in data collection. According to authors Kitzinger (1995) and Morgan (1997), heterogeneity within each focus group is crucial to avoid a power dynamic that could prevent some participants from contributing. As a result, first-line managers at Band 7 were excluded from the study.

Chief nurses and national nursing leaders were chosen as the third phase population due to their ability to contribute to the long-term strategic context.

5.2.7. Rationale for context (hospital nursing)

The study context was set within hospital nursing as this is an area where little nursing research has taken place. Staff in teaching hospitals were reasoned to potentially have greater exposure to technology and therefore RN Focus Groups were planned for two teaching hospitals and two non-teaching hospitals in order to compare different viewpoints. The study was geographically located in England as four Chief Nurses of English NHS Trusts indicated their provisional support to the Director of Studies prior to ethical approval. They had been approached purposively as they were known contacts (my peers) and pragmatically this simplified the HRA approval process. There was also a concern initially that comparing data across type of hospital and across countries with differing approaches to technology would add an additional layer of complexity to analysis. The move to an online method offered greater flexibility to combine participants across groups, but removed the option to compare between groups.

5.2.8. Patient and Public Involvement

Patients were not formally included, although were initially considered in the study design as one of the phases. Informal discussion of the study with a patient involvement group in Warwick in October 2019 had been positive and influenced the study design to explore patient perspectives during one of the phases. Including patients and relatives was very important to me, however this would have added additional phases and complexity to the study design which became prohibitive time-wise for a doctoral study during COVID-19. Patient and public perspectives have also been more widely researched as discussed in chapter 3. The study was narrowed, somewhat reluctantly, to nurses as the principal users of robots.

5.3. Data Collection and Analysis: Phase 1 Roboticists

5.3.1. Phase One Data Collection: Interview Method

The primary objective of Phase 1 was to provide insight into potential scenarios of future robot capabilities for subsequent phases. To collect data, three qualitative methods were considered: interviews, focus groups, and surveys. Interview method was chosen due to its ability to answer complex questions, provide clarification, and allow for exploration of inference, which surveys cannot provide (Vogt, Gardner, and Heaeffele, 2012). Interviews are defined as a conversation between two individuals for the purpose of gathering original data (Gubrium and Holstein, 2001). They have several advantages over surveys, including question flexibility, response rate, and ease of organisation compared to focus groups (Hofisi, Hofisi, and Mago, 2014). The ability to explore inference through interviews was considered crucial for making estimations about the future and is congruent with a constructionist methodology and therefore interviews were used for the first Phase.

While Gubrium and Holstein (2001) suggested that interview methods have been adapted to various theoretical purposes without issue, Fadyl and Nichols (2013) argued that consistency with theoretical paradigms as primacy. Interviews enable 'verbal construction through interaction between the researcher and the participant' (Gergen, 2009, p. 44), making them congruent with social construction. Online interviews have additional advantages, such as capturing non-verbal cues (Sullivan, 2012), but could pose technological challenges and a more disruptive environment (Deakin and Wakefield, 2014).

The reliability of interviews as a method has been criticised due to the potential for variation (Hofisi, Hofisi and Mago, 2014). However, Robson (2002) argued that variability can be advantageous, as it allows for the modification of questions and follow-up on interesting responses, leading to a deeper investigation of underlying responses. In addition, non-verbal cues observed in face-to-face interviews can reveal meanings that would not be apparent in a questionnaire survey.

5.3.2. Recruitment of Roboticists (Phase 1)

Participants for the study were recruited using purposive sampling, a method appropriate for selecting individuals with specific knowledge or experience (Vogt, Gardner and Haeffele, 2012). Although this method may introduce bias, Morgan (1997) argues this to be acceptable providing results are not presented as a full spectrum of expertise, which this study does not. To be clear, the inclusion of the Roboticist phase was to provide an indication of future capability only. Six universities with strong robotic development programs were identified, and an initial email was sent to university contacts by a member of the supervisory team. Of the four universities that responded, five roboticists were sent the participant information and consent form.

5.3.3. Roboticists Inclusion and Exclusion Criteria

All respondents met the inclusion criteria detailed below in Table 5.3 and therefore no exclusions were required.

Table 5.3. Inclusion and Exclusion Criteria for Roboticists Phase 1

Table: Roboticist Inclusion and Exclusion Criteria	
	Inclusion and Exclusion criteria
General Inclusion Criteria (all participants)	1. Interested and available to participate on the selected dates and times 2. Able to give informed consent 3. Able to speak and understand English 4. Access to web-based mobile technology to contribute to online interviews
Specific Inclusion criteria	5. Roboticists, Robot Developers and Robotic engineers including post graduate students and industry partners who are involved in robot design and development. 6. Leaders of a department, research or development programme in Robotic development 7. Understand potential future robotic (and/or artificial intelligence) capability
Specific Exclusion Criteria	8. Undergraduate roboticist students will be excluded .

5.3.4. Roboticist Participants

The sample size was intended to be small based on the observation that (during the Winston Churchill Travel Fellowship) there was considerable consensus on robotic capability. It was intended that 4 interviews could provide either a consensus view or the identification of a range of opinions. One participant also referred a colleague so a total of 5 (male) roboticists from 4 universities took part.

5.3.5. Generating and conducting the interview schedule

The roboticists interview schedule /question guide was designed to move from the general to specific as recommended by Stewart and Shamdasani (1990) as detailed in Table 5.4. The opening question aimed to discover if there was a preferred definition or common understanding of a robot. Subsequent questions explored the current contribution of robots and future capability including discussion on the taxonomy, its usefulness and how it could be refined for use to enable articulation of future capability. Finally, a closing question invited further comments or observations.

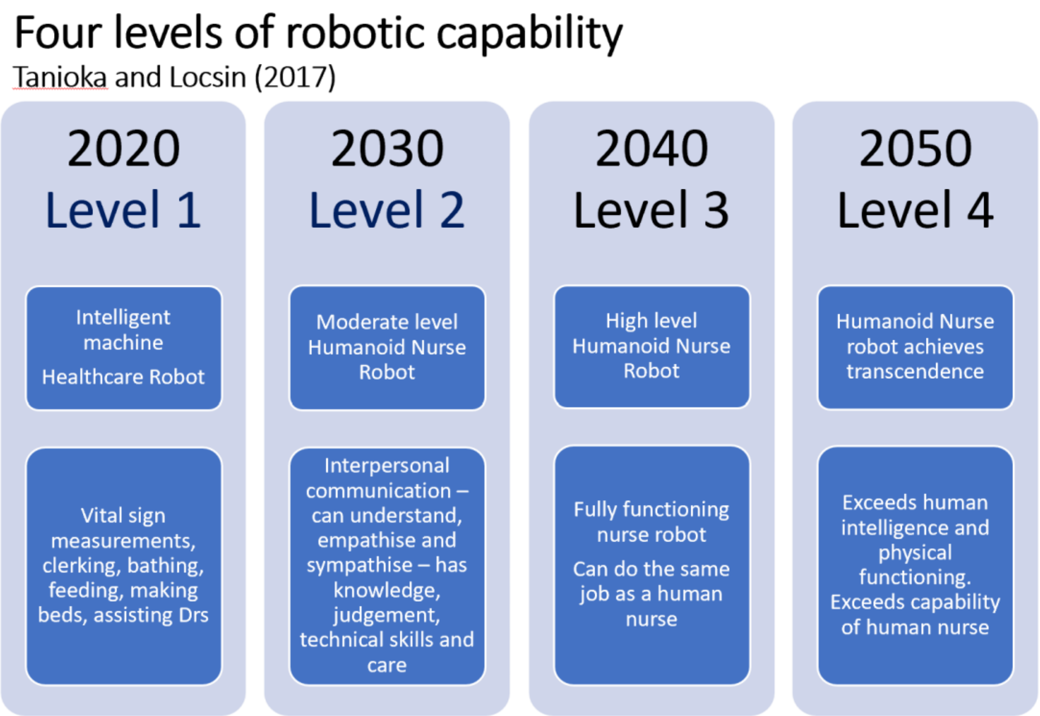
Table 5.4. Roboticist interview Schedule.

Table: Roboticists Interview Schedule
1. Perhaps we could start with a definition of a robot. How do you define a robot?
2. Based on your knowledge of robot applications how do you think robots could be applied in a hospital care environment today?
3. What new technology developments do you envisage over the next 10 -15 years that might have an impact in a hospital care setting?
4. Are you aware of any challenges arising from the COVID-19 pandemic that might be addressed by the use of robotics technology
5. I've drafted some ideas of levels of automation based on the automotive autonomous vehicle levels – would you be prepared to take a look and comment on the timescales for the technologies and the likely developments in each level? a. Is this a reasonable definition? b. What technology examples would you put this category? c. How might capability change in the next 10-15 years?
6. Other comments

Categorisation of robots differed between authors and the appropriate functionality for robots in nursing has not yet been defined and even within functions, a range of capability exists. Therefore, it was recognised that a conceptual model was needed to frame discussions on robotic capability.

One approach was proposed by Tanioka and Locsin in 2017 (illustrated in Figure 5.2). Their trajectory of four levels of robotic maturity for nursing proposed that robotic capabilities would increase incrementally each decade until reaching a hypothetical point called "the singularity" in 2050 (Tanioka and Locsin 2017). This is a point where humanoid nurse robots are expected to surpass human capabilities and potentially even manage human nurses. However, this trajectory was underdeveloped, and no validation or testing has been reported. Moreover, even if the trajectory was separated from the predictive decades, the model does not provide clarity on the level of autonomy. Nonetheless, autonomy is a crucial concept in nursing, and is clearly referred to in professional frameworks such as The Code (Nursing and Midwifery Council 2018).

Figure 5.2. Illustration of Levels of Nursing Robots (after Tanioka and Locsin 2017).

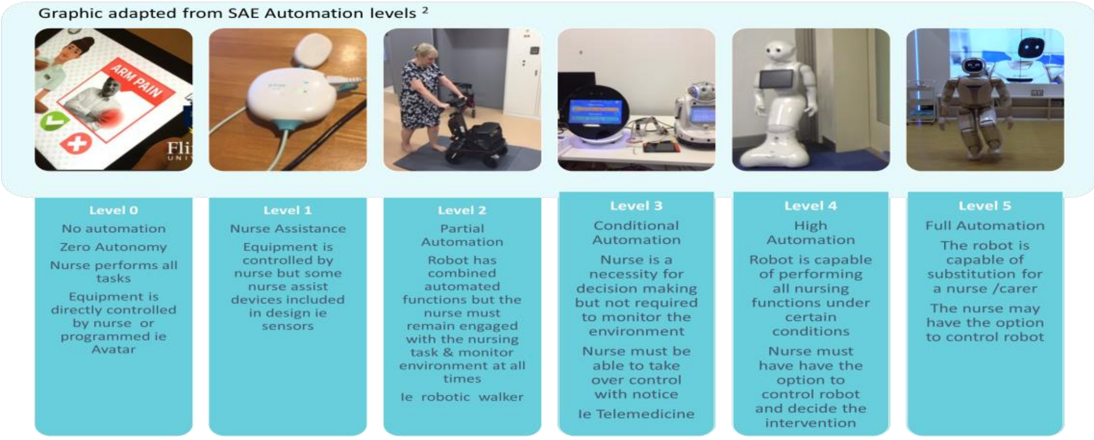


Constructed from: : Tanioka and Locsin (2017) *Nursing Robots: Robotic Technology and Human Caring for the Elderly.* Fukuro Shuppan Publishing. Okayama City p236-241

5.3.6. An Alternative Framework: Taxonomy of Automation

In 2017, an editorial in Science Robotics highlighted the adaption of the SAE (2016) categorisation of self-driving cars into 6 levels of automation (Yang *et al.,* 2017). This inspired my development of a similar categorisation of robotics in nursing. I envisaged this serving as a discussion tool so that roboticists could indicate which level robotic development had currently been reached and at what level robots might be expected to function in the next 10-15 years. This alternative is presented in Figure 5.3. and is more granular than Tanioka and Locsin's work and perhaps less predictive and alarmist.

Figure 5.3. First draft of a Taxonomy to Illustrate of Levels of automation of Nursing Robots (adapted from SAE 2016).



Whilst the taxonomy above was specifically developed for nursing, a number of other taxonomies had previously been developed for automation, e.g., Sheridan and Verplank, (1978) and Endsley and Kaber (1999), each proposed ten levels of automation from manual control to full automation. These taxonomies, however, were designed to consider autonomy in decision-making, rather than autonomous physical actions. Parasuraman, Sheridan, and Wickens in 2000 developed a decision-making model to determine to what extent tasks could be automated (Beer *et al*., 2014). In common with other taxonomies, their model treated tasks as a single event and therefore was less useful when considering ongoing processes such as in nursing. Essentially, these models categorise activities, rather than robot functionality and focus on automation rather than autonomy whereas both automation of tasks and autonomy, (level of control), are key factors in nursing decision-making.

Yanco and Drury (2002) developed a taxonomy based on the premise that higher levels of autonomy were related to lower levels of human-robot interaction. Others disagreed, arguing that the more sophisticated a robot is, the more sophisticated interaction with humans needs to be (Thrun, 2004; Fiel-Seifer, Skinner and Mataric 2007; Goodrich and Shultz 2007). Beer, Fisk and Rodgers (2014) also suggested that the level of robot autonomy defined the required frequency and format of interactions with humans. They helpfully defined robot autonomy as:

> *"the extent to which a robot can sense its environment, plan, based on that environment, and act upon that environment with the intent of reaching some task-specific goal (either given to or created by the robot) without external control*" (p. 3).

This emphasised three components of sense, plan and act which underpin a number of the other frameworks or taxonomies.

Thereafter, Beer, Fisk and Rodgers (2014) proposed a taxonomy based on the model developed by Huang *et al*., (2005) for military and security applications, and included dimensions related to the complexity of the task and the complexity of the environment which are both relevant to nursing. Their taxonomy included a batch processing level which is not relevant to nursing and decision support level software related (Beer, Fisk and Rodgers (2014). In contrast, the taxonomy developed for this study **is** specific to nursing and comprises six levels with both automation and autonomy as central concepts but incorporates the components of sense, plan, and act. This taxonomy formed part of the interview schedule for roboticists and was shared in advance with all participants.

5.4. Roboticist Data Analysis

Individual interviews were arranged by email with each roboticist and were conducted during October and November 2020 using Zoom conference platform lasting between 23 and 47 minutes. Four of the participants contributed with their camera on, and a fifth participant was travelling so participated mostly camera-off.

5.4.1. Transcription

All interviews were transcribed using the auto transcription facility on Zoom. These preliminary transcripts required substantial correction particularly when participants had strong accents as the software was less accurate. This was resource intensive (6-10 minutes for each 60 seconds of audio time) but enabled familiarisation with the data. This was undertaken by the researcher, de-anonymised and checked for accuracy by one of the supervision team. The audio-visual recording was then deleted in accordance with the ethical approval.

5.4.2. Analysis

The aim of the analysis was to identify a working description of a robot and to identify the likely future developments and capabilities of robots that could be applied to nursing. Analysis looked for commonalities or consensus as well as divergence or differences between perspectives. Thematic analysis focuses on the content of qualitative data and seeks to draw out themes and explanations (Gale *et al*., 2013). Ritchie and Spencer (1994) developed a comparative form of thematic analysis called Framework Analysis (Goldsmith, 2021) which uses a matrix or framework of summarised data to enable visual comparison across data sets. This method was further articulated as a seven-stage approach, best suited to interview data, by Gale *et al.,* (2013). This seven-stage approach to Framework analysis was used as follows:

Stage 1 Transcription

> Gale *et al*., (2013) suggest a good quality audio transcription is required. Extensive amendment of the Zoom auto-transcription was necessary for accuracy but had the benefit of enabling immersion in the data.

Stage 2 Familiarisation with the data

The transcription process assisted with familiarisation as each part of the recording was listened to (and the video observed) multiple times to ensure the transcript was accurate. In addition, the corrected transcripts were read at least twice prior to coding.

Stage 3 Coding

Line-by-line coding was undertaken by the researcher and code labels (a paraphrase or word describing the phrases or sentence) were annotated to each piece of text. Coding was two-phased: initially predominantly deductive (closely related to the interview questions) and secondly inductively to enable themes generation.

Stage 4: Developing a working analytical Framework.

This was initially developed related to the interview questions and revisited later in the study as a significant time had elapsed following the initial interviews.

Stage 5: Applying the analytical framework

This was a two-part process, with the initial analytical framework developed shortly after the roboticist interviews and the second revision following the completion of the registered nurse focus groups. This revision necessitated re-coding and re-analysis of the data.

Stage 6: Charting the data into the matrix

The initial process of summarising and charting data was commenced after the initial analytical framework was produced. This was repeated following the re-coding of the data set as there had been an interval of 16 months and additional experience in analysis had been gained.

Stage 7: Interpreting the data.

Initially, this was completed deductively with themes mirroring the questions from the topic schedule. However, the first draft of the interpretation was revisited and reconsidered with a focus on a more inductive approach, albeit the additional knowledge and perspectives gained from the subsequent fieldwork also introduced a degree of implicit deduction. The results of Phase 1 are presented in chapter 6.

5.5. Focus Group Method Phase 2 (Registered Nurses) and Phase 3 (Nurse Leaders)

Smithson (2000) argued that choice of method should be based on getting the best data for the research question and this section considers the rationale for the selection of focus group method for both phases 2 and 3. Data collection needed to allow for the development of ideas and perspectives rather than simply extracting opinions, and the method also needed to be congruent with the methodology of social construction (Braun and Clarke, 2021b).

5.5.1. Rationale for use of focus groups

According to Morgan (1997), focus groups are defined as '*research technique where a group interacts to provide data on a topic chosen by the researcher*' (p6). This method was described by Bogardus in 1926 when it was initially referred to as group interviews (Lee, 2008). These were used to determine the effectiveness of propaganda during World War II and later in marketing research (Morgan, 1997). Since then focus groups have evolved into a qualitative method that generates rich data (Asbury, 1995).

As an alternative to interviews, focus groups aim to generate ideas and opinions where they have yet to be formed. Hence focus group method is a suitable way to explore new topics, as group interaction can generate valuable data and insights (McDaniel and Bach, 1994; Hennink, 2013). The method was chosen because it allowed observation of interactive processes, (Kitzinger, 1994), and enabled participants to share their perceptions, attitudes, and insights on the potential role of robots in future nursing care (Litosseliti, 2003). This approach to knowledge creation aligned with social construction, as outlined by Wilson and Hutchinson (1996).

Online focus group methods have demonstrated advantages in terms of time efficiency and geographical coverage, as noted by Tuttas (2015a). Archibald *et al*., (2019) also reported that, even prior to COVID-19, online technology offered more advantages than disadvantages for collecting qualitative data. Reid and Reid (2005) compared computer-mediated communication with conventional face-to-face focus group methods and found that, while fewer words were spoken online, the volume of ideas and solutions was greater.

5.5.2. Critique of Focus Group Method

There have been several criticisms of focus group methods, including their lack of generalisability, difficulty in reaching data saturation, and issues with confidentiality and handling sensitive data. Additionally, measuring the strength of opinion and inferring consensus from focus group data can be challenging, as group interaction can influence opinions. However, such criticisms appear to be based on positivist values, indeed the ability to influence opinion was seen as an advantage in this study as it mirrored the conversation that might naturally occur in the clinical environment. Therefore, the focus group method was chosen as it gave participants the discussion and thinking time which allowed them to form opinions, modify, or strengthen viewpoints through conversation, and enabled the researcher to capture a range of perspectives.

5.5.3. Size of Focus Groups

The optimum size for a focus group has been addressed by a number of authors: Morgan (1997) and Smithson (2000) suggested between 6 and 12 participants, which was supported by Krueger (2002) slightly smaller recommendation of 5 to 10 with an optimum size of 6-8 preferred. Kitzinger (1995) however argued that larger groups may silence individual voices of dissent and advocated a smaller group size of 4-8.

Ritchie and Lewis (2014) also addressed small focus group size and suggested that whilst groups of less than 4 participants lose some of the group dynamics, two and three-person groups also yield rich data. This was supported by Lobe and Morgan (2021) who found that two-person groups were easier to moderate and enabled better interaction and more honest expression of thoughts. Whilst four-person groups yielded more contributions, there was a greater tendency towards shorter statements of simple agreement or disagreement (Lobe and Morgan, 2021). Tuttas (2015a) also commented that whilst online platforms enable larger group sizes, larger group sizes could result in serial contributions rather than an interactive group discussion.

In this study, it was particularly important to hear any voices of dissent and therefore a smaller focus group size of 4-6 was aimed for. However, even this smaller number was difficult to recruit in both nurse phases: Only 5 of the 9 planned RN focus groups and 2 of the Nurse Leader Focus Groups had three or more participants. Anticipating the possibility of further participants dropping out on the day, ethical approval was obtained for single-participant interviews in the eventuality that only one participant attended. This meant that smaller dyad (two-person) and triad (three-person) groups were also permissible. Small focus group size was found to be effective in enabling interaction (Toner, 2009; Morgan *et al.*, 2016).

Tables 5.9 and 5.14 detail the actual number of participants in each focus group for each phase.

5.5.4. Number of Focus Groups

A number of authors suggested the number of focus groups should be guided by data saturation. Saturation is obtained by continuing to sample until no new substantive information is acquired (Miles and Huberman, 1994). Kruger (1994) and Morgan (1997) suggested that three to six groups may be adequate to reach saturation which was similar to Kitzinger's (1995) confirmation that most questions could be answered by 6-8 groups although 4 groups were adequate for some studies. Tuttas (2015b) similarly reported reaching saturation after 4 online focus groups of 2-5 participants.

Conversely, Braun and Clarke (2021a) suggested that data saturation should not determine sample size, labelling it as a form of positivism creep underpinned by realist assumptions of data redundancy and generalisability which do not fit with qualitative approaches. Instead, they argued that because meaning is generated from interpretation the decision to stop data collection is subjective. Malterud, Siersma, and Guassora (2015) reiterated this point in relation to social construction arguing that knowledge is '*considered partial, intermediate, and dependent of the situated view of the researcher*' (p7). Furthermore, Morse (2015) argued that sample size in qualitative studies cannot be determined in advance and should be reviewed throughout the study. For this study it was acknowledged that further data may add to the findings and therefore data saturation cannot be claimed.

The major determinant of sample size was participant availability. In Phase 2 focus group dates continued to be offered until all interested RNs had been offered multiple dates on three or more occasions, including a final call giving 4 further date and time options. At this point, recruitment of interested participants was considered to have been exhausted. Data were reviewed and considered rich and multi-faceted, and thereafter collection of data were considered complete. In Phase 3, participant availability was again the major determinant, and data were reviewed after four groups which were considered adequate.

5.5.5. Role of Moderator or Facilitator

One of the distinguishing features of focus groups is the role of the facilitator or moderator. The moderator role is to conduct the focus group including asking the questions (Doody, Slevin and Taggart, 2013), outlining the group rules at the beginning (Kreuger and Casey, 2009), and continuously directing the conversation towards the topic of interest (Unger, Nunnally and Willis, 2013).

Stewart, Shamdasani and Rook (2007) pointed out that the moderator role is key to collecting rich insights from participants. Pushta and Potter (2004) identified three key skills for moderators: Producing Participation, Producing informality and Producing Opinions and this practice of moderation was a significant source of reflexivity which is discussed in section 5.11.

5.5.6. Pilot focus groups

Two pilot focus groups were undertaken at the beginning of data collection to test the topic schedule, the conference technology and improve researcher confidence in troubleshooting the technology. Tuttas (2015b) advocated practicing to gain familiarity and pilot the topic schedule for discussion.

The first pilot focus group comprised two (very insightful) student nurses and confirmed the ease of technology use and suitability of topic questions. Feedback from the second pilot group (comprised of four experienced postgraduate nurses drawn from the student researcher fraternity) resulted in changes to the topic schedule to explicitly refer to elements of the Fundamental of Care Framework (Feo *et al*., 2017). No data from pilot online focus groups were included in the data collection.

Having presented the methods common to data collection in Phase 2 and 3, section **5.6** considers the details of Phase 2 data collection followed by section **5.7** which describes Phase 3 data collection.

5.6. Phase 2: Registered Nurses Data Collection

5.6.1. Registered Nurse (RN) Population

The population of nurses for Phase 2 comprised Registered Nurses working at Band 5 or Band 6 in acute inpatient wards or departments.

Table 5.5. Inclusion and exclusion criteria for Registered Nurses.

Table: Inclusion and Exclusion Criteria for Phase 2 Registered Nurse Participants	
General Inclusion Criteria (all participants)	1. Interested and available to participate on the selected dates and times 2. Able to give informed consent 3. Able to speak and understand English 4. Access to web-based mobile technology to contribute to online interviews or focus groups* *For those without technology or telephone access arrangements were offered for a face-to-face focus group for Registered Nurses.
Specific Inclusion criteria	5. UK Registered Nurses working within a 'hands on 'clinical care on a daily basis within an acute hospital trust 6. Band 5 and 6 Adult Hospital Nurses settings delivering clinical inpatient care on a daily basis.
Specific Exclusion Criteria	7. Registered nurses who are not in a hands-on care environment on a day-to-day basis will be excluded 8. Theatre nurses, occupational health and outpatient nurses will be excluded because the nursing role differs significantly within these environments. 9. Registered Nurses primarily with management responsibilities i.e. sister/ charge nurse in charge of unit on a daily /continuing basis will be excluded

5.6.2. Phase 2. RN Recruitment

Six hospital trusts were identified at the beginning of the study as potential sites as the Chief Nurse (or deputy) was known personally to the researcher. Three teaching hospitals and three non-teaching hospitals were contacted purposefully by the Director of Studies and four agreed to take part. One Trust was later unable to facilitate on-site recruitment due to ongoing COVID-19 restrictions, so another was substituted in (with ethical and Research and Development department approvals).

Recruitment of RNs took place between January and June 2022 and featured many attempts to overcome the challenges of multiple lockdowns and stretched NHS services due to the COVID-19 pandemic. Table 5.6. details the five discrete approaches which were tried (with the requisite approvals) from January to June 2022 each using a convenience sampling approach except the referral approach which was an example of purposive sampling:

- Hospital recruitment by displaying by poster and including in newsletters in four hospital trusts, with the posters reissued to include a QR code. Three potential participants came forward from one site.
- Email invite letter was sent to nurses on hospital trusts 'preceptorship' lists (newly qualified nurses) with no response. This was followed up by an online presentation to preceptees in one Trust – again with no response.
- Social Media Advert placed (3 rounds) on Twitter and two Facebook groups which targeted membership of newly registered nurses. Six further nurses expressed an interest and four RNs returned signed consent forms.
- Referral by sending invite letter to Royal College of Nursing colleagues by a management member and two people expressed an interest.
- Onsite face to face recruitment following the lifting of COVID-19 restrictions was conducted in four Trusts (one replacement).

Table 5.6. Steps for each of the five recruitment methods.

Table: Step by step process, for 5 methods of RN Recruitment					
Step	**Trust recruitment**	**Email/ Presentation to Preceptor-ship groups**	**Social Media recruitment**	**Referral**	**Face to face recruitment**
1	Hospital Trust puts up posters and includes advert in internal communication	Trust sends introductory email to preceptorship mailing lists	Study advertised on social media	Colleague forwards introductory email to colleagues at RCN	Researcher visits wards/ departments accompanied by member of R&D team
2	Interested RN use email or QR code to contact researcher	Interested RN replies by direct message or email to researcher	Interested RN replies by direct message or email to researcher	Interested RN replies by direct message or email to researcher	Researcher asks nurse in charge permission to talk to RN's on duty
3	Researcher sends Introductory letter, Participant Information Sheet, Consent Form to RN by email	Researcher sends Introductory letter, Participant Information Sheet, Consent Form to RN by email	Researcher sends Introductory letter, Participant Information Sheet, Consent Form to RN by email	Researcher sends Introductory letter, Participant Information Sheet, Consent Form to RN by email	Researcher approaches RN and gives overview of study in 2 mins, leaves participant information & consent forms
4	Consent form signed by RN and scanned or photographed and returned by email to researcher	Consent form signed by RN and scanned or photographed and returned by email to researcher	Consent form signed by RN and scanned/ photographed and returned by email to researcher	Consent form signed by RN and scanned/ photographed and returned by email to researcher	Consent form signed by RN and collected by researcher an hour later (or sent by post to researcher)
5	Researcher canvasses RN by email for availability for dates/times	Researcher canvasses RN by email for availability for dates/times	Researcher canvasses RN by email for availability for dates/times	Researcher canvasses RN by email for availability for dates/times	Researcher canvasses RN by email for availability for dates/times
6	RN identifies convenient dates/times	RN identifies convenient dates/times	RN identifies convenient dates/times	RN identifies convenient dates/times	RN identifies convenient dates/times
7	Researcher sends out link for focus group	Researcher sends out link for focus group	Researcher sends out link for focus group	Researcher sends out link for focus group	Researcher sends out link for focus group
8	Researcher sends out two reminders 3 days and one day plus morning of focus group	Researcher sends out two reminders 3 days and one day plus morning of focus group	Researcher sends out two reminders 3 days and one day plus morning of focus group	Researcher sends out two reminders 3 days and one day plus morning of focus group	Researcher sends out two reminders 3 days and one day plus morning of focus group
9	Thank you and link to personal data form sent to attendees with further comments form and NMC reflection form	Thank you and link to personal data form sent to attendees with further comments form and NMC reflection form	Thank you and link to personal data form sent to attendees with further comments form and NMC reflection form	Thank you and link to personal data form sent to attendees with further comments form and NMC reflection form	Thank you and link to personal data form sent to attendees with further comments form and NMC reflection form
10	New dates sent to non-attendees	New dates sent to non-attendees	New dates sent to non-attendees	New dates sent to non-attendees	New dates sent to non-attendees

In total 79 consent forms were given to interested RNs across four sites and 58 were completed and collected, 5 were returned blank and one further consent form was received by post. Morgan (1997) made the valid point that recruitment isn't as simple as identifying participants who agree to take part but comprises a series of planned activities to ensure attendance. Of the 70 RNs expressing an interest, 20 did not give any availability, 4 withdrew citing workload /time commitments and 21 indicated availability but were unable to attend at a later date. Four male and twenty-one female RNs took part in Phase 1.

Table 5.7. details recruitment by method and Table 5.8 details recruitment by site.

Table 5.7: Method of Recruitment				**Table 5.8: Site Recruitment**		
Method	**Nº of RNs interested**	**Nº of RN's who took part**		**Site**	**Nº of RNs interested**	**Nº of RN's who took part**
Local Recruitment by NHS Trust	3	1		Site 1	8	4
Preceptor group	0	0		Site 2	15	7
Social Media	6	4		Site 3	18	4
Personal referrals	2	2		Site 4	20	6
On site face to face recruitment	59	18		Social Media/ Other	9	4
Total	**70**	**25**		**Total**	**70**	**25**

5.6.3. RN Sample

Twenty-five RNs took part across 9 focus groups. Only one person attended focus group 3, and 9 and part of 5 and these were conducted as interviews. Table 5.9 details the number of participants expected to attend each focus group and the number of participants attending.

Table 5.9. Number of Participants in each Focus Group

Table: Phase 2 RN Participants per Focus Group									
	Focus Group One	Focus Group Two	Focus Group Three	Focus Group Four	Focus Group Five	Focus Group Six	Focus Group Seven	Focus Group Eight	Focus Group Nine
Invited/ Availability confirmed	5	5	4	5	4	4	7	4	2
Attended	3	4	1	3	2 ->1 *	2	6	3	1

Table 5.10 gives an overview of the number of focus groups with 1, 2, 3, 4, and 6 participants.

Table 5.10. Overview of Phase 2

Table: Phase 2 Numbers of RN participants per Focus group					
Interviews (one participant)	Focus Groups with 2 participants	Focus Groups with 3 participants	Focus Groups with 4 participants	Focus Group with 5 participants	Focus Group with 6 participants
2 ->3*	3 ->2*	3	1	0	1

*Focus group commenced with 2 participants but one participant lost connection, leaving one participant who continued as an interview

5.6.4. Phase 2 RN Focus Group Topic Schedule

This schedule was developed in line with recommendations by Morgan, Krueger and King (1998) and included Opening Questions, Introductory Questions, Transition Questions and Key Questions. The schedule included an overview of the results from Phase 1 (the definition and future capability of robots). It was amended following testing in the pilot focus group and the final version used for the RN Focus Groups is reproduced below in Figure 5.4.

Figure 5.4. Registered Nurse Focus Group Schedule

Registered Nurse Focus Group Schedule
Facilitator covers 1. Welcome, Thank you and Introductions 2. Explanations of Facilitator & Observer role 3. Confidentiality and non-attributability 4. Consent / audio recording /use of data 5. Refreshments and timescales 6. Written comment form 7. Follow up / copy of report
Opening Question • Can you tell us your first name and the clinical area in which you work?
Introductory Question • What were people's first impressions when thinking about the topic of the focus group today?
Transition Questions • Thinking about recent events and COVID: Are there any areas where Technology might have helped? • This research is asking people to think 10-15 years ahead. What do you think will be some of the key challenges for nurses? • How might nursing be different 10-15 years ahead? • What might be the role of technology in the future?
Key Questions • What do you think the role of robots should be in delivery of therapeutic nursing care in the future? • Open pack -explain terminology of robot and initial findings from Robotocists • Looking at the Fundamentals of Care what elements could a robot do? • What elements should Robot not do? • Lets talk through a couple of the Fundamentals from each domain and think through different robot capabilities or levels of automation and what we think about what a robot should /should not do…. • What would you need to know about robots to enable your use of them? • What things might concern you about robots in healthcare? • What might be some benefits of robots in nursing?
Ending Questions • What have we not discussed that is relevant here? • What other comments would you like to make?
Thank you and next steps

Section **5.7** now details the data collection for Phase 3 Nurse Leaders

5.7. Phase 3 Nurse Leader Data Collection

5.7.1. Nurse Leader Population

Phase 3 of the study sought to recruit senior nursing 'thought' leaders with accountability for strategy development including Chief Nurses. Chief Nurses are the most senior nurses in an NHS Trust, working at executive level on the Board of health organisations, who strategically plan the workforce of the future. These posts are labelled as Very Senior Manager or VSM in the NHS. The study also purposively sought to include national nursing leaders with a similar strategic responsibility referring to this group collectively as 'Nurse Leaders'. Table 5.11. details the inclusion and exclusion criteria for this Phase.

Table 5.11. Phase 3 Inclusion and exclusion criteria

Table: Inclusion and Exclusion Criteria for Phase 3 Nurse Leaders	
General Inclusion Criteria (all participants)	1. Interested and available to participate on the selected dates and times 2. Able to give informed consent 3. Able to speak and understand English 4. Access to web-based mobile technology to contribute to online interviews or focus groups*
Specific Inclusion criteria	5. Chief Nurses and Directors of Nursing who hold an UK role that includes strategic oversight of nursing either as a chief nurse in an NHS hospital, executive nurse for a group of independent hospitals or in a national nursing leadership role. 6. Previous experience at least at deputy director of nursing in the NHS. This is because some post holders (particularly in the private sector) have significantly less strategic experience and will not be included. 7. National leaders of nursing
Specific Exclusion Criteria	1. Retired chief nurses who do not hold a current strategic role will be excluded. 2. Senior nurses holding a chief nurse title but without strategic oversight as a core part of their role will be excluded.

5.7.2. Nurse Leader Recruitment

Successful recruitment employed three purposeful recruitment methods. Firstly, purposeful contact from my Director of Studies to the Chief Nurses of each of the Phase 2 Hospital Trusts. Secondly, the Shelford Group of Chief Nurses (a group of 10 large teaching hospital trusts) was approached as I have previously been part of this network. Availability was problematic and some delegated their invitation to their CNIO (Chief Nurse Information Officer), a newly created role in larger hospital Trusts following the appointment of a CNIO for England. Thirdly by referral: personal contacts passed on a tentative invitation to colleagues. The study was also advertised unsuccessfully three times on social media. Tables 5.12 and 5.13 indicate the number of participants, recruitment method and their role.

Table 5.12. Number of participants by recruitment method

Table 5.13. Professional Role of Nurse Leader Participants

Table 5.12: Phase 3 Nurse Leader Recruitment	
Method of recruitment	**Nº of nurse leaders who took part in study**
Purposeful recruitment invitation via DoS	5
Social Media	0
Personal referrals	3
Shelford Group	4
Total	**12**

Table 5.13: Phase 3 Nurse Leader role	
Nurse Leader Role	**Nº of nurse leaders who took part in study**
National Leader (Independent Healthcare)	1
National Nursing Organisation Executive	1
National Nursing Leader	3
Chief Nurse/ Chief Nursing Officer	5
Chief Nursing Information Officer	2
Total	**12**

5.7.3. Nurse Leader Sample

Twelve senior nursing leaders took part in four focus groups. This sample size was again driven by availability and pragmatism. All initially interested nurse leaders were offered multiple dates and after four focus groups, the data were considered adequate. Whilst the voluntary demographic data request was not completed by any participant, two of the nurse leaders were male and 10 were female which is a slightly higher proportion of male leaders than the national percentage of between 8 and 15% of management positions in nursing held by men.

Table 5.14. Nurse Leader Participants in each Focus Group and

Table 5.15. Number of Focus Groups with 2, 3 and 5 participants.

Table 5.14: Phase 3 Nurse Leader Participants per focus Group				
	Focus Group One	Focus Group Two	Focus Group Three	Focus Group Four
Invited & Availability confirmed	3	4	4	5
Attended	2	3	2	5

Table 5.15: Phase 3 Nurse Leader Participants per focus group		
Focus Groups with 2 participants	Focus Groups with 3 participants	Focus Group with 5 participants
2	1	1

5.7.4. Nurse Leader Focus Group Topic Schedule

The topic schedule (Figure 5.5.) was developed in line with the reference guide by Morgan, Krueger and King, (1998) and included a short presentation (***Appendix 5***) of the results from Phase 1 and 2.

Figure 5.5. Nurse Leader Focus Group Topic Schedule

Chief Nurse Focus Group Topic Schedule
Facilitator covers • Welcome, Thank you and Introductions • Explanations of Facilitator role • Confidentiality and non-attributability/ Personal Information request • Consent / audio-video recording/ use of camera /use of data • Using chat function for written comments • Follow up / copy of report
Opening Question 1. Can you tell us your first name and the type of Trust/ setting you work in?
Introductory Questions 2. When we think of the future 10-15 years ahead – what issues do we need to consider? 3. What was your initial reaction when thinking about the topic of the focus group today?
Presentation of findings from the Registered Nurse Focus Groups
Transition Questions 4. Are you aware of any challenges arising from the COVID-19 pandemic that might be addressed by the use of robotics technology? 5. How has technology adoption changed? 6. How might nursing be different 10-15 years ahead? 7. What might be the two or three major challenges for nursing 10-15 years ahead? 8. What new technology developments do you envisage over the next 10 -15 years that might have an impact in nursing?
Key Questions 9. How do you think robots could be used in nursing care? 10. What considerations/ preparations do we need to make? 11. What things might concern you about robots in healthcare? 12. What might be some benefits of robots in nursing? 13. As leaders – what should we make happen in the next 10-15 years? 14. Any red line /must not do areas?
Ending Questions 15. What have we not discussed that is relevant here? 16. What other comments would you like to make? 17. Today we have used online technology for this focus group – any comments you'd like to make about this method?
Thank you and next steps

Having presented how the online interviews and focus groups were conducted, Section **5.8**. gives a short reflection on the use of online methods.

5.8. Reflection on use of Online Focus Group Method

The use of online method worked well and had some advantages over traditional methods. Whilst the move to online was driven by the necessity to remove face-to-face contact during the pandemic, the advantages of auto-transcription and watch-back were very helpful to me as the researcher. In the focus groups the online approach attempted to mimic the face-to-face approach and to a large extent the conference platform made it possible for all participants to see each other, all the time. Whilst there was perhaps less interaction between participants than might have occurred face-to-face, the advantages of the platform meant that I could see all the participants on screen. I could also view each group again enabling me to immerse myself in the data as Gale *et al*., (2013) and Braun and Clarke (2021b) advise. It also enabled scrutiny of expressions and non-verbal cues in other participants whilst one person was speaking which may not have been possible without a co-facilitator in a face-to-face scenario. The video function also enabled members of the supervisory team to observe each focus group and interview at a later date without impacting the group dynamics. One of the focus groups had six participants and there was some evidence of shorter answers in this group which confirmed the findings by Tuttas (2015b). Conversely, smaller focus groups generated detailed discussions.

5.8.1. Difficulties with Technology

Whilst technological difficulties were expected, they were minimal with only three participants in Phase 2 experiencing issues. For one, the sound quality was poor, and they needed to move computer terminal to be heard. For another, the signal was lost shortly after a small child approached the participant's laptop. And for a third who joined by mobile, the camera position faced the ceiling which meant that her contribution was predominantly verbal.

Having considered data collection for phases 2 and 3 section 9 discusses the method of data analysis (thematic), followed by outlining of the process for both Phases 2 and 3.

5.9. Analysis of Focus Group Data: Thematic Analysis

The decision on the method of analysis of the focus group data were centred on what output from the analysis would be most useful to future policy and practice. This involved multiple discussions and reflections (one example of this reflection is included in ***Appendix* 6**).

Bennett, Barratt and Helmich (2019) suggested qualitative analysis can be undertaken in two ways, through a focus on the content or a focus on how language is used. Content i.e. what might be the role of robots? was considered to be more important as this is a developing research area. This discounted both content analysis (as it focuses on the ***language*** used) and discourse analysis (as it focuses on ***how*** a phenomenon is discussed). Instead, the focus of this research needed to be on the '**what'** of robotic roles and nurses' perceptions and the analysis method also needed to allow analysis across the data set.

In contrast to the Roboticist data, which was analysed using framework analysis to enable comparisons between participants, all focus group data were considered together in each phase. Reflective Thematic Analysis (TA) was selected for RN and Nurse Leader data analysis as it was congruent with social construction and had the following strengths (drawn from Braun and Clarke 2021b p.261):

- Works well with a large range of datasets and group sizes
- Enables inductive or deductive analysis
- Well suited to a cross-case orientation (i.e. considering all data as one set of data and analysing together)

- Easy to learn for the novice researcher
- Well suited to single researcher analysis

A further reason for choosing reflective thematic analysis was Braun and Clarke's (2021b), perspective on research subjectivity, which they regard as an asset. This aligned with Gergen's (2015) vision of the researcher's role as not simply '***shining the mirror'*** but '***shaping the future'*** (p.6).

Analysis was predominantly inductive to avoid missing new perspectives or knowledge which had yet to be considered which could have resulted in an 'impoverished analysis' (Braun and Clarke, 2021b). However, the Fundamentals of Care Framework was used deductively in the analysis of nursing activities.

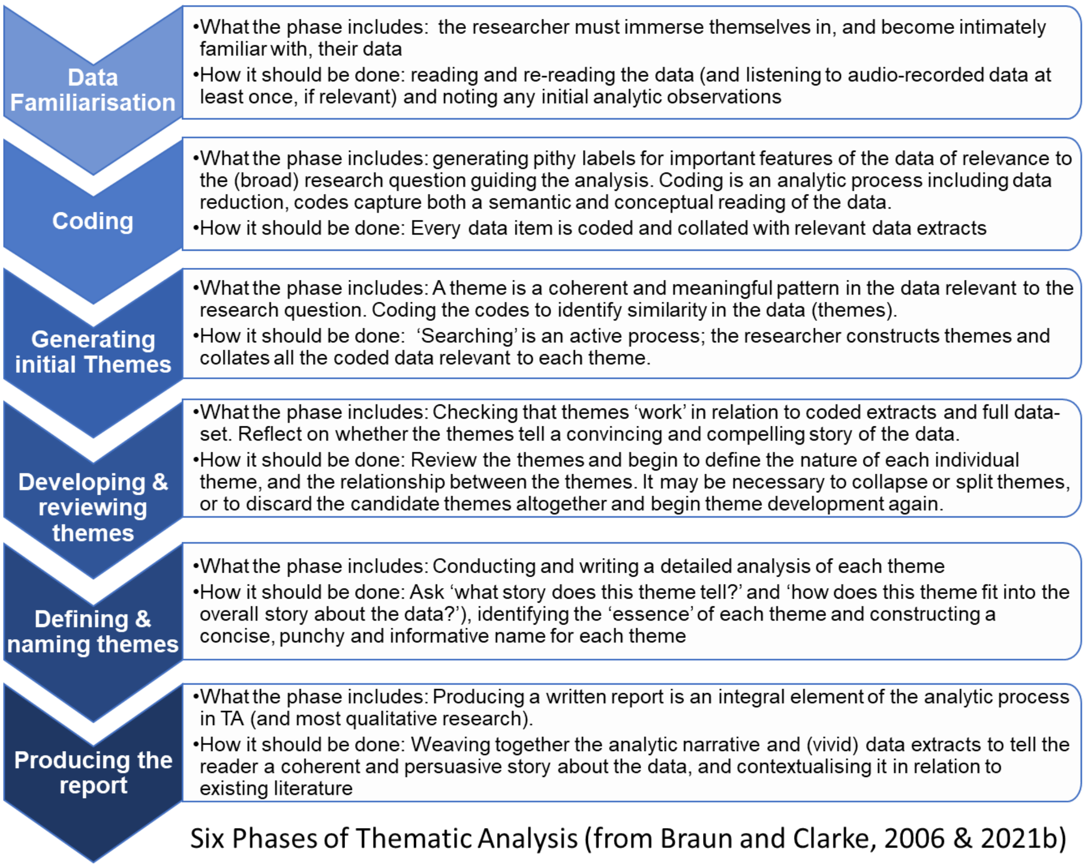
5.9.1. Critique of Reflective Thematic Analysis

In common with the critique of all qualitative methods, reflexive Thematic Analysis (TA) findings are not generalisable to a wider population i.e. nursing. However, having accepted that qualitative methodology is more appropriate in generating meaning and understanding of future perspectives, it was accepted that results may be transferable but not generalisable.

5.9.2. The process of Reflexive Thematic Analysis

This study used a six-stage process (Braun and Clarke, 2006), to analyse the data. These six Phases are illustrated in the Figure overleaf.

Figure 5.6. Six Phases of reflective thematic analysis



Six Phases of Thematic Analysis (from Braun and Clarke, 2006 & 2021b)

The next sections describe how this six -phased process was undertaken in this study for both Phase 2 and 3 of data collection which both used focus groups.

5.9.2.1. Familiarisation with the Data.

Each interview or focus group was transcribed in full, using the conference platform 'Zoom' auto-transcription functionality. As with phase 1 interviews the auto-transcription was checked and amended by rewatching the video and correcting the text manually, taking 6 to 10 minutes per minute of audio. Non-verbal observations were added manually such as laughter, nodding or disagreement including shaking the head or facial expressions like frowning. This process enabled a deep familiarisation with the data as video recording allowed repeat viewings so that the focus group could be re-experienced and participant reactions reviewed.

5.9.2.2. Coding.

Corrected transcripts were hand coded systematically line by line, by reading and adding 'code labels' (defined as a 'succinct phrase' by Braun and Clarke, 2021b p53) to interesting aspects of text relevant to the research question. Efforts were made to code at both the semantic and latent levels.

The transcripts were then loaded into NVIVO 12 (software tool for qualitative analysis) and recoded in reverse order, in accordance with the recommendations of Braun and Clarke (2021b). In the RN dataset this second coding generated some 535 code labels across the nine datasets (focus groups and interviews) with multiple duplicates. This list was tidied up and duplicate codes and data were merged.

Despite this rationalisation, the large number of codes (or nodes in NVIVO) was difficult to visualise on screen so the code label list was printed and cut up into strips and organised manually. This meets the recommendation to use more than one approach to generate themes (Braun and Clarke, 2021b).

The same process was followed for the nurse leader dataset but fewer codes were generated.

5.9.2.3. Generating initial Themes.

Braun and Clarke (2021b) made the point that the process is not necessarily linear and this was true in this study, in that for the RN dataset a recoding of the data was needed after the first tentative or 'candidate themes' had been identified. This was done through NVIVO, reviewing each of the transcripts in a different order again from the middle (5th) data file outwards.

The Nurse Leader dataset was more straight forward and indeed one of the 'candidate' themes- that of 'the unique contribution of nurses' was articulated directly by participants across focus groups.

5.9.2.4. Developing and Reviewing Themes

This phase included reviewing each of the 'candidate' themes and returning to the dataset and individual codes for each potential theme whilst considering if there was a better way of organising the data. Braun and Clarke (2021b) describe this as a recursive process, and this was particularly evident when reviewing the theme of 'fear' as there were many dimensions to how 'fear' was described by participants, not all of which related to robots.

5.9.2.5. Defining and naming themes

This phase was iterative and comprised a number of discussions firstly with the supervisory team, and secondly (following presentation at a conference) with conference attendees. This resulted in merging two of the robotic roles and renaming one of the themes in the RN dataset. This process continued with the nurse leader dataset with an initial five themes condensed into three which reflected the key assertions by nurse leaders.

5.9.2.6. Production of the report

Results of the reflective thematic analysis are presented in Chapter 7 with the reflective process continuing throughout and presented in section 12 of this chapter. Having considered the data collection and data analysis of the three phases, sections 5.10 and 5.11 consider the ethical and quality considerations of this study.

5.10. Ethical Considerations

Richards and Schwartz (2002) conceived the ethical issues for qualitative research from the perspective of risks to the participants: anxiety and distress, exploitation, misrepresentation and confidentiality. Orb *et al*., (2001) articulated considerations in terms of the researcher's responsibilities to protect participants. The principal ethical considerations for this study were those of protection of participants, and the wider principles of respect for autonomy, informed consent, and confidentiality which are considered in turn below.

5.10.1. Protection of participants

Whilst this was a low-risk study and arguably lower due to the online nature of participant contact, provision was still made for support in the event of anxiety or distress and this was referred to in the participant information. No issues were observed during the study.

5.10.2. Respect for Autonomy

The design of the study ensured voluntary participation in two ways – firstly by separating the invitation from the person that potential participants responded to. This removed the potential for participants to feel they must contribute due to a dependent relationship with either the initial contact (chief nurse, regional nurse or supervisory team) or the researcher. Participant information also made clear the voluntary nature of the study and the right to withdraw at any time (***Appendix 7***). The difficulties of removing participant contributions individually from the focus group data sets were spelt out and comprised part of the consent. Autonomy was further respected in face-to-face recruitment, by giving a period to decide whether to opt in or not i.e. "*I'll come back in an hour*" and by giving a further 'cool off' period of at least 5 days between recruitment and the first focus group date.

5.10.3. Informed consent

This was taken from every participant in the form of a detailed participation information sheet (for example: ***Appendix 7***) and completed written consent (for example: ***Appendix 8***). Furthermore, participation in the study was taken as consent and confirmed with participants prior to turning on the recording function on the Zoom Conference platform.

5.10.4. Confidentiality

This was assured by the secure storage of identifiable information such as participants contact details and scanned copies of the consent forms on a University Google Drive which was password protected. Within the focus groups, whilst I could give an undertaking of confidentiality, this could not be assumed on behalf of participants and therefore each focus group began with a brief request for commitment to non-attributability with an example of what could and should not be shared outside the focus group.

5.10.5. Data Storage

In addition to the consent forms and participant details, the corrected anonymised transcripts of the interviews and focus groups have been stored in the University approved Google Drive. Zoom digital recordings were stored automatically in the cloud for 30 days prior to auto deletion and a password was applied in the interim. The Oxford Brookes Data Management policy requires anonymised data to be retained for 10 years or more from when the last request to access was made. Therefore final research data (of anonymised transcripts and an NVIVO download will be offered for deposit and retention in the Radar repository with a Brookes data custodian appointed. A data management plan will also be created to govern the future use and storage of data. Given the subject matter, the data use will be restricted to non-commercial purposes and will specifically exclude derivates and data use for training AI models.

Personal identifiable data such as names, and contact details should only be kept for the minimum necessary period (Data Protection Act 2018). Therefore, this identifiable information will be deleted from the secure Google drive three months after completion of study close documentation (unless further University guidance requires alternative procedures). Consent forms will be redacted of personal identifiable information such as names, contact details and signatures and the redacted scanned versions included within the retained information above. This is because consent forms given permission for the data to be held.

5.10.6. University and Health Research Approval

The study was granted ethical approval through University and Health Research Authority (HRA) mechanisms (***Appendix 9***). Capability and Capacity Assessment approval was obtained from each Trust research and development departments. Several amendments were made to the original design and formally approved by the University and HRA.

5.11. Quality considerations

In quantitative research the criteria of trustworthiness (rigour, reliability, validity and generalisability) have largely been accepted. However, the criteria for quality in quantitative research proposed by Lincoln and Guba (1985) prompted ongoing debate about how quality should be assessed in qualitative research. Guba and Lincoln (1989) proposed credibility, which they suggested parallels internal validity, transferability (which parallels external validity), dependability which parallels reliability and confirmability which parallels objectivity. These have since been operationalised by others (Silverman, 2006; Amankwaa, 2016). Jasper (1994), Appleton (1995) and Morse (2015), all advocated rigour as an important determinant of quality research and Morse (2015) proposed a return to the quantitative titles of reliability, validity and generalisability but Schwandt (1996) rejected a criteria-based approach in favour of transparency and openness in interpretive approaches. It is clear that data collection, analysis and interpretation *were* seen by some as threats to validity because of the subjective and variable nature of these processes (Morse, 2015). However, Braun and Clarke (2021b) argued that such processes are by nature subjective and should be acknowledged as such.

5.11.1. Trustworthiness

In order for this research to have credibility and validity due attention was given to a process of developing trustworthiness through the process of research as well as asserting the credibility of the researcher (Patton, 1999).

Tracy (2010) advocates eight 'big tent' criteria as '*universal hallmarks for high quality qualitative methods*' (p837) which were subsequently recognised by Braun and Clarke (2021b) as helpful and congruent with reflexive TA. Therefore, a Trustworthiness protocol was developed as suggested by Amankwaa (2016), **(*Appendix 10*)** following the content of the Tracy (2010) big-tent criteria. These eight criteria are: Worthy topic; Rich Rigour; Sincerity; Credibility; Resonance: Significant contribution; Ethical and Meaningful coherence, which are discussed below.

5.11.2. Worthy topic

The introductory and background chapters of this thesis laid out why this topic is relevant and timely in terms of the significant workforce challenge and technological advances. Tracy and Hinrichs (2017) suggested that in order to be worthy a topic must be relevant and timely, and significant and interesting. The topic of robots is often described as interesting, perhaps due to the novelty, and this research promised to be significant in that no previous research had been found that is UK orientated and it was hoped that the results would inform and drive debate.

5.11.3. Rich Rigour

Hennink (2013) argued that rigour is achieved by detailing the procedural steps and methodological decisions and challenges. Tracy (2010) appeared to agree, referring to rigorous data collection and analysis procedures including transparency of process. Cohen and Crabtree, (2008) and Tracy (2010) also focused on the quality of research both in terms of its contribution and significance and in the rigour of the method and analysis. Although Morse (2015) argued that increasing generalisability should be the aim and responsibility of the researcher, pursuing generalisability could be argued to be considering rigour from a more quantitative perspective of reducing bias (Johnson 1999). In this thesis, pursuit of generalisability of findings was offset by the pragmatics of time but the processes of data collection and analysis were reported in full, contributing to methodological rigour.

Richness can also refer to data and Weick (2007, p.16) described rich explanations and descriptions as:

> *'bountiful, generous and unstinting with the generation of richness linked to the use of theoretical constructs and variety of data sources and samples'.*

Morse (2015) emphasised the importance of developing thick rich description to ensure validity. The inclusion of three phases and two different nursing populations in multiple focus groups generated an abundance of data which were shaped into themes and complex descriptions pertinent to nursing and to the role of robots. This complexity contributed to the richness as does the face validity of the study which Golafshani (2015) defined for qualitative research as the extent to which the study appears to be reasonable and appropriate.

5.11.4. Sincerity

For Tracy (2010) the criteria of sincerity includes the key practice of reflexivity as well as vulnerability, honesty, transparency and data auditing. Richardson (2000) cited reflexivity as one of five primary criteria of research quality, suggesting that researchers need to demonstrate self-awareness and self-exposure so that the reader can make judgements. A reflexive journal was commenced at the conception of this study and comprised multiple field notes including commentary on feelings and sensemaking in the first person (meeting recommendations by Emerson, Fretz and Shaw, 1995). Whilst transparency was viewed as a key component of sincerity by Tracy (2010), Krizek (2003) warns against personal catharsis in reflexive accounts. As a novice researcher, my reflexive journal contained a high degree of personal catharsis, therefore some elements were 'culled' for inclusion in this thesis. Those remaining have the intention of illuminating understanding rather than illustrating the personal impact of the study's challenges (Krizek, 2003).

Tracy (2010) exhorted researchers to be both honest and vulnerable and suggested weaving reflective considerations through the research report. My reflexive accounts do detail my vulnerabilities, particularly in terms of focus group conduct and moderation and present the challenges of recruitment during a time of intense pressure for the NHS.

5.11.5. Credibility

Tracy (2010) included trustworthiness, verisimilitude and plausibility in the criterion of credibility. Whilst verisimilitude and plausibility could be argued to be determined by the reader, trustworthiness was a well-documented criterion of rigour (Johnson, Adkins and Chauvin, 2020). Thick description is a key component of trustworthiness and in this study was approached by both the visual and written depiction of key themes. Tracy and Hinrichs (2017) also referred to multivocality as a feature of credibility and this study included the voices of different levels of nurse.

The iterative study design enabled a degree of crystallisation from different types of data, i.e. both verbal and non-verbal, albeit this was limited within the focus groups. However, the study presented multivocality in the differing voices of RNs and Nurse Leaders.

Tracy (2010) advocated member reflections as a step towards credibility, however, Morse (2015) counselled against this, arguing that it may impact the data. The video recording of the data collection which was a feature of this study enabled the cross-checking of the data collection by supervisors. However, the analysis of what this data means was acknowledged to be subjective and following Braun and Clarke's (2021b) assertion that this is an asset if combined with reflexivity, this was accepted. The iterative design enhanced credibility as it enabled feedback on one phase of the study by the subsequent participants. Results have also been presented in conferences of nurse leaders and students **(*Appendix* 14)** and at face value, results have been described as interesting and credible.

5.11.5. Resonance

According to Tracy and Hinrich (2017), resonance helps the reader to make connections with the themes and findings. The phased approach to this study enabled nurse leaders to review the findings from the RNs and there were a number of contributions that voiced their resonance and understanding. The presentation of results in graphic and written form were intended to aid the aesthetic merit which Tracy and Hinrich (2017) argued to be helpful to developing resonance.

5.11.6. Significant Contribution

The study size, qualitative nature and narrowed focus (to acute hospital nursing) prevents a wider generalisability of findings. However, the taxonomy of autonomous robots and the robotic roles may be transferable to other branches of nursing including community and mental health settings. This therefore represents a contribution to future practice and more importantly to future debate about the role of robots in nursing.

5.11.7. Ethics

This measure of quality is, according to Tracy and Hinrich (2017) made up of procedural ethics, situational ethics, relational ethics and care and thoughtfulness following data collection and in the report completion. Whilst procedural ethics were covered in section 9 of this chapter, it was important to me to act ethically as a researcher. These situational ethics covered such aspects as decision-making on recruitment - how far to push and how far to respect people saying they were too busy. This is explored further in the reflexivity sections but in essence, I pushed harder on gatekeepers for access than on participants. I was particularly keen to reassure participants that were less keen that it was okay to decline, and I was grateful for their consideration. Ellis (2007) identifies the need for awareness of the researchers' actions on others. I was particularly aware of this in my introduction in face-to-face recruitment where in the first site I was encouraged to use my chief nurse background but was mindful of creating a power dynamic. I opted to mention this but play it down "*I have been a chief nurse in the past*" and play up my current doctoral student role "*but now I am a student looking at the role of robots in nursing*". This is discussed further in section 5.12. below.

5.11.8. Meaningful Coherence

This aspect of Tracy's (2010) big tent criteria referred to the overall consistency, soundness and rationality of the study and had parallels in the recommendations of paradigmatic coherence (Lincoln and Guba, 2000). This study had a focus on being future forming by inviting people, particularly nurse leaders, to start to debate the topic. The study was underpinned by a social construction approach and as such expects that discussions might continue.

In summary, quality criteria suggested by Tracy (2010) have been considered and whilst there are some questions about transferability to other fields of nursing, this study meets most of the criteria for a trustworthy qualitative study. It does have a number of limitations, and these will be further explored in Chapter 12.

5.12. Reflexivity

Reflexivity refers to the researcher's practice of examining their own position within the research, including its potential impact on the setting, the individuals being studied, and the data collected (Berger, 2015). Throughout my doctoral process, the ability to reflect on and process data, information, and knowledge has been essential. This process has been a source of joy, and it aligns with the notion of reflexivity as the most important companion, as described by Braun and Clarke (2021b). Though it is not intended to be cathartic, there are times when the notes, thoughts, and recriminations in my reflective journal could indeed be described as such. As recommended by Tracy (2010), specific learning has been woven throughout this thesis. Therefore, this section will follow Wilkinson's (1988) three types of reflexivity: personal reflexivity, functional or methodological reflexivity, and disciplinary reflexivity.

5.12.1. Reflection on Personal Values

I consider myself to be someone guided by strong values. I strive to be compassionate towards others having been appalled by the findings of the Francis report, (2013) and I prioritise making people feel appreciated and supported. Honesty, integrity, and authenticity are principles that I always aim to abide by, regardless of whether or not others value them. While I don't identify as religious, I believe in a God who is present and engaged in the world. The impact of these personal values on knowledge production is that I tend to value the opinions of others highly and seek to understand them. However, I valued my own reflections less, so the process of reflective thematic analysis was more time-consuming than anticipated.

As a student researcher, I was aware of my novice status. Initially during recruitment, I refrained from mentioning my background as a chief nurse, but noticed some caution among frontline nurses to my introduction as 'a nurse researcher', possibly due to the association of nurse researchers with medical research. On the first site, the research and development manager observed this hesitancy and suggested that I 'use' my chief nurse background. I was initially uncomfortable with this as I didn't want nurses to feel coerced. I settled on describing myself as having been a chief nurse in the past, labouring the past tense and emphasising that I was **now** a doctoral nurse student, looking at robots in nursing. This was remarkably successful, the level of caution in talking to me, visibly dropped and more people expressed interest.

Similarly in the focus groups, I was aware of a potential power imbalance from a knowledge perspective as my knowledge of the topic area had inevitably developed. Whilst I cast myself in the role of co-contributor, I had to regularly remind myself that the role of the researcher is not to convey my viewpoint but to find out from others what they think. I have been helped in this regard by my parallel working life which involves teaching and coaching leadership behaviours, one element of which is to ask curious open questions. Due to the benefits of online video recording, I was able to re-watch and reflect on each focus group and interview which has been pivotal in personal development for me.

5.12.2. Methodological reflexivity

5.12.2.1. Recruitment difficulties.

As the first COVID-19 lockdown was announced, I recognised that I would have to redesign the data collection process but initially didn't appreciate how this would impact recruitment processes too. The biggest challenge I faced during this time was the ethical dilemma of whether it was right to ask exhausted nurses to contribute to my study on the future of nursing while they were dealing with the present crisis. Although the redesign and approval process took a long time, my biggest concern was balancing the possible benefits of the study against the potential harm to the participants. Despite my best efforts, recruitment was unsuccessful until the lockdown measures began to ease and I was able to recruit on-site. At this point, I was able to see the reactions of would-be participants first-hand. Some participants still declined, but others told me they were eager to talk about something other than COVID-19. This is a key observation, I seriously considered if it was ethical to explore this at a time when nurses were most vulnerable, but nurses described being keen to look forward and have a say in the future and that created a responsibility to continue.

Given that the recruitment was difficult and in one trust no-one came forward from a group of 80+ newly registered nurses, suggests that the views obtained may not be comprehensive and this was a limitation which may have limited knowledge creation. On the other hand, this research at least starts nurses thinking about this so that they might have a voice.

5.12.3. Theoretical tension

In the previous chapter, I identified my leaning towards critical realism and my decision to use social construction to address the research question. The method worked well for the creation of knowledge and the results illuminate some of the intrinsic thinking and perceptions that were alluded to but not evidenced by previous quantitative research.

My admiration of quantitative research, primarily because of the generalisability of results was also a point of tension from a methodological perspective in this research. During a discussion about my presentation of research results, my supervisors suggested that I count the number of positive or negative responses to provide an approximation of how strongly the issue was held. Despite my extensive reading on reflexive thematic analysis which would suggest this as an inconsistent positive approach to analysis, I was also keen to justify my results by offering a more numerical perspective on the qualitative research responses, likely also due to an innate desire to please. However, I ultimately realised as a researcher, my role was to present the range of responses, not just those that were significant numerically. This realisation was a key moment in my development as a qualitative researcher and one that enabled me to appreciate the importance of research congruence.

5.12.4. Reflexivity on disciplinary location

As a nursing leader and researcher, one of the most challenging aspects was viewing nursing through the lens of others. During each focus group and upon reviewing the recordings, I noticed various quotes and perceptions that I agreed with and wanted to highlight. However, I encountered perspectives that I disagreed with, particularly regarding aspects of nursing, which in my opinion, should not be automated. As a researcher, it was crucial to give others a voice, even if I did not share their views. Nevertheless, as a nurse leader, I also have a responsibility to act in the best interests of patients as outlined by the Nursing and Midwifery Council (NMC 2018a). Therefore, I have carefully and accurately presented all controversial results (as evident in the FOC graphics in ***Appendix 13***) with the aim of offering a balanced perspective in the discussion chapter.

One of my supervisors commented that I appeared to have written the chapter on roboticists results from a position of huge relief, relief that experts confirmed that robots cannot replace nurses within the next 10 to 15 years. This immensely helpful challenge prompted me to firstly review the chapter and secondly to lay out my personal perceptions below of what I thought robots could do in the future both at the beginning of the study and as I write up the results.

5.12.4.1. Initial Perspective on Robots in Nursing

At the beginning of the study, I believed that robots could assist in certain physical aspects of care, such as lifting and handling, but I had concerns about their manual dexterity and physical limitations. I was intrigued to learn about the ceiling-mounted robots being developed at Bristol University. However, I was hesitant about the idea of robots providing any form of relational care. This changed when I participated in the Winston Churchill Travel Fellowship and was informed that robots may soon possess the same level of interactional capability as humans.

5.12.4.2. Current Perspective on Robots in Nursing

Over the last three years, I have moved my position. I believe that robots can be very useful in monitoring patients, whether through telemonitoring or as a partial substitute for one-on-one care. Robots will have the ability to monitor vital signs and support patient care, with the added benefit of being able to directly download results into the clinical record. I recognise the importance of nurses assessing patients, including their vital signs, and believe that nurses should continue to undertake these safety-critical skills while utilising technology to assist them. I am however clear that if robots are to be used in patient care, they must have the same level of skill and expertise as human nurses. While I personally prefer human-to-human care, I am open to robots assisting at a higher level of autonomy providing robots can provide the same quality of care. However, for me (as a result of this study) the role of nurses in teaching nursing is sacrosanct.

5.12.5. Reflexive Journaling

Given that I have situated this research in the realm of strategic nursing leadership a key part of my reflexive journaling was to reflect on each nurse leader focus group both immediately after it had finished and again during the analysis stage. These reflections are reproduced in ***Appendix 12*.**

5.13. Chapter summary

This chapter described the overall study design as an iterative three phases approach with three discrete populations: roboticists interviews, registered nurses focus groups and nurse leaders focus groups. The rationale for the data collection method of interviews and focus groups has been described. The chapter then described the data analysis of focus groups. The next chapter presents the first phase of results – that of the Roboticist interviews.

Chapter 6: Roboticist perspectives

6.1. Introduction

This chapter presents the framework analysis (Gale *et al.*, 2013) from the five roboticist interviews which were conducted online in early 2021 as Phase 1 of the Study. The purpose of these interviews was to estimate technically the feasibility for the 10-15 year timeframe considered for this study. Transcribed contributions were coded, grouped into themes and presented in four matrices by theme:

1. Definition of a robot
2. The purpose of technology and robots
3. Robotic Development -where are we now and where will we be in 10-15 years (using the taxonomy)
4. The challenge of complexity and unstructured environments.

An overview of the themes is presented in Table 6.1 and ***Appendix 11*** contains an example (for definitions) of the framework of full contributions and summary text.

Table 6.1. Code table comprising themes codes and summary statements

Table: Themes, Codes and Summary Statements		
Theme	**Codes**	**Summary statement**
Definition of a robot	Definition	A robot is defined as an electromechanical device that has sensors, actuators (or a motor to move) and a computer.
The purpose of robotic technology	Releasing time	Robots can perform some assistive functions for mundane, repetitive tasks, releasing the professional time to focus on more complex tasks
	Improving Outcomes	Robotic capability can support human endeavours to improve outcomes
	Augment human capability	Robots can augment human capability in lifting, moving and handling and in supporting human dexterity, information processing & data management
	Avoid transmission of infection	Robots were not well developed at the time of the COVID-19 pandemic so had a limited role but the fetching and carrying capabilities and telemedicine /teleoperation capabilities have potential for future pandemics
The value of a taxonomy	Values of taxonomy	The taxonomy provides a useful framework for further discussions
	Where are robots now?	Currently at level 1-2
	Where will robots be in 10-15 yrs?	Expected to be at level 2-3 with some specialised robots at level 4
The challenge of complexity	The challenge of the unstructured environment	Robot autonomy is limited in an unstructured environment due to the many millions of variations and permutations, Currently environments are designed for humans but smart environments (robotic enabled) may enable greater use of robotics /technology
	The limitations of current robots	Current robots are limited by their sensing capability and understanding, this limits the role and functions that can be undertaken by a robot to tasks within a very structured environment or within fixed parameters
	The complexity of nursing	Roboticists had a good understanding of the nurses role as varied, patient facing and referenced 'hard, important and complex' activities. Nursing work was referred to as tasks meaning that a reductionist perspective might prevail in robotic development
	The challenge of substitution	There was consensus that robots would not be able to substitute for nurses in the next 10-15 years but could take on a helpful assistive role

Presentation of the results is followed by a short discussion about the high-level overview of robotic capability now and in the future, which informed the discussions with nurses in Phase 2 and 3. Where quotes from roboticists have been included, these are identified as roboticist 1 (R1), roboticist 2 (R2) etc.

6.2. Theme one: How roboticists defined robots

During the roboticist interviews, the initial question was about the definition of a robot. Most respondents believed that a robot's appearance did not define it. They agreed that the common misconception was that robots had to be humanoid in shape or appearance. Some examples given were the concentric tube (snake) robot and smart buildings:

> "*We have to get away from thinking of robots as having arms and legs*," (R5).

Roboticists agreed that a robot's shape or appearance was dependent on its function, e.g., "something like hands to grab things." (R5). However, all suggested that the physical appearance may vary, depending on the application and the patient interaction. Roboticists defined robots based on their capability (what it can do) and their functionality (what it is for).

Table 6.2. Roboticists definitions of a robot

Table: Roboticist Definitions of a Robot	
Roboticist 1	'A machine which can sense the environment and act on it to produce some some behaviour'
Roboticist 2	'An electromechanical system that moves, programmed by your computer, composed of motors to move and sensors to perceive something in the environment'
Roboticist 3	'Robots are a machine that can sense its environment, or a limited aspect of its environment and then react to it, either by action or by talk something, some sort of interaction with the environment is required'
Roboticist 4	'A device that performs a relatively well defined task within certain parameters, it maybe hardware or software or even biologically based'
Roboticist 5	'It's a spectrum of machines which can perceive its environment and make decisions based on its perceptions to do things in the real world (physical things or speech actions), sensing environment and making some sort of decsisions

It was interesting to note that among the four roboticists who defined a robot by its capability, they each used terms such as machine, system, or device, with three referring to it as a machine. One roboticist (R2) emphasised the importance of including motors and sensors in a robot, with motors being necessary for movement and sensors for perceiving the environment. He also made the distinction between robots and artificial intelligence, stating that the former must have both motors and sensors and the latter being a computer programme which corresponds with the definitions in the literature.

Regarding a robot's interaction with its environment, various definitions were given. One roboticist referred to the action generated by the robot (R5) while others cited movement or behaviour elicitation. Some included speech actions, and one suggested that a biological molecule could act as a motor for a biological robot. However, all definitions emphasised a robot's ability to act, react, or perform specific tasks within specific parameters which again accorded with literature definitions.

Interestingly, two roboticists (R1, R5) used the metaphor of a washing machine as a robot, with one stating that it can sense the environment and act on it to produce some behaviour (R1). They also highlighted that automation and intelligent decision-making are key to helping humans, regardless of whether the robot has arms and legs or not. One roboticist described a robot functionally as a tool to operate remotely, with the ability to operate at a distance from the operator (R4).

Overall, the roboticists' emphasised the importance of a robot's capability to perform specific tasks with the help of motors and sensors. Irrespective of the definition, all agreed that in the future the computer element of robots would likely incorporate some form of artificial intelligence as standard.

6.3. Theme two: the purpose of robots

Four drivers of robotic development were articulated in the interviews: the use of technology to release time, improve outcomes, augment human capability, or to reduce infection risk as Table 6.3 shows:

Table 6.3. Roboticist views on the purpose of robots

Table: The purpose of technology (robots)	Releasing Time	Improve outcomes	Augmenting Human Capability	Avoiding transmission of infection
Roboticist 1	A robot can perform assistive tasks so that staff can use the time to do something harder requiring human judgment.		Use robots for logistics such as delivering medication, give staff reminders and checking patients and reporting back	Robots cannot contract infection so can go into infected patient rooms
Roboticist 2			Teleoperated robots can eliminate fatigue and robots may provide physical support in moving and handing tasks	Robots could perform covid test for patients
Roboticist 3	Robots could undertake logistic tasks such as delivery of food or delivery/removal of linen	The Da Vinci surgical robot may improve speed and clinical outcome of surgery	Robots can manoeuvre equipment such as C arm	Although unprepared, robots could off load the risk of infection and carry out disinfection
Roboticist 4	Robots can release time by automating mundane tasks and freeing up professional time for more interesting tasks	Robots can improve patient selection for treatment		Robots could help with data and infection prediction
Roboticist 5	By partially automating some tasks it gives people more time to spend on more interersting and difficult issues	Robots can detect events and patterns using machine learning and provide alerts. In-utero robots are in development to improve outcomes for spinabifida surgery	Smart technology in buildings could identify people at risk of injury	Technology can provide Covid information in a more digestible way

The first driver of robotic development was to release time, and four roboticists suggested that automating repetitive or tedious tasks could potentially allow nurses to concentrate on more interesting and judgment-intensive work. The second justification was to improve outcomes, and reference was made to robots such as the Da Vinci surgical robot and an in-utero tube robot. Roboticists cited other examples which seem to highlight the capabilities of artificial intelligence rather than being specific to robots. Thirdly Roboticists each suggested examples of how robots can augment human abilities. One was the use of surgical robots, while another was the provision of reminders. The fourth rationale for the development of robots referred to the very specific function of avoiding transmission of infection.

The roboticist interviews took place shortly after the first COVID-19 lockdown and therefore a number of comments were made about robots having advantages over humans as they could not catch COVID-19 or pass it on. One roboticist (R1) suggested that robots could play a role in reducing the spread of COVID-19 through telemonitoring, where a robot would be with the patient and the clinician would communicate with the patient through the robot, thus minimising face-to-face interactions that could lead to cross-infection.

6.4. Theme three: The value of a Taxonomy

Before conducting interviews with roboticists, the SAE diagram for self-driving cars (2019) was adapted to apply to the nursing environment. The taxonomy developed for this study was based on the adaptation by Yang *et al.,* (2017) and included six levels of automation with example pictures. This was shared with the roboticists prior to their interviews (see ***Appendix 12***) and discussed during each interview. Each level in the diagram represents a higher level of automation, and, similar to the original SAE levels, implies a continuum from no automation to full automation. The term "taxonomy" was used for this framework as it denoted a classification scheme and avoided suggesting that higher levels are a goal or target, as the alternative term ‘trajectory’ implies. It was also noted that one of the roboticists described robots as existing on a continuum (R1).

Table 6.4. shows the summarised responses of each roboticist; firstly, their feedback on the taxonomy, secondly their estimation of the current level of robotics, and thirdly their future estimation of robotic capability in the next 10-15 years.

Table 6.4. Value of the Taxonomy, Where are we now and where will robots be in 10-15 years

Table: Value of Taxonomy, Automation level of robots now and in 10-15 years?			
	Value of Taxonomy	**Automation level of robots now?**	**Automation level in 10-15 years?**
Roboticist 1	Very, very clever actually, we've missed something in the community and this is something that you know could become the new standard	We are at level one, some at level two'	We are in one, in 15 years we will be moving to two
Roboticist 2	It's helpful I think, it was very good	I think level zero and level one. It's something we have already	Level two and level three are very good target, we have solutions already. Level four and five could be interesting for some specific tasks.
Roboticist 3	This makes alot of sense, if people have this taxonomy in mind, they can think about it more seriously.	I mean, there is no level two really, not that I know of, I don't know any level two, You could have a walking device and a walking device is level two.	Three for sure and I think we will be playing with level four. [level five] Yes at some point we will, I'm sure we will even if it takes maybe fifty years,
Roboticist 4	I think it will be vital to have a framework where to place these technologies on, just so there is a strategy in the future, and I think it will probably help frame what happens over the next 15 years		Robotics should get cheaper. Battery life is not a problem that robotics will solve.
Roboticist 5	I think these levels do make sense.	I guess I mean level three.	I don't see many nursing tasks that will be completely automated by a robot..We have some existing specialised systems for both level two and level three, Level 5 is science fiction.

All roboticists were positive about the taxonomy and its potential value in assisting further discussions. In general, each roboticist interviewed understood the levels and differences between them. One postulated that it could be developed to be a new industry standard (R1). Beer, Fisk and Rodgers (2014) critiqued other taxonomies for under-specifying the intermediate level and consequently included ten levels in their taxonomy. A similar critique could be levelled at the taxonomy developed for this study, indeed, one roboticist (R5) commented that the difference between level 4 (autonomy within a controlled environment) and level 5 (autonomy within an unstructured environment) was significant. However, the similarities to the six-level self-driving car taxonomy appeared to aid understanding.

6.4.1. What robots can do now?

Roboticists were asked to outline the current capability of robots with particular application to the hospital environment and responses highlighted possibilities for both social and physical support. In terms of social support roboticists suggested that social robots could be employed to support patients in a hospital setting and made reference to digital assistants such as Alexa, and Google Nest providing social support and suggested that these could be adapted to support clinicians and other health care professionals in hospital settings (R1, R4, R5). One hypothetical scenario suggested was a nurse calling out:

> "*Hey Google remind me to ask Occupational Therapy to visit Mr Jones*" (R5).

When discussing physical support, roboticists primarily referred to the limitations but one mentioned robotic beds, lifting devices and toileting devices (R1).

There was a range of views on the degree of autonomy and automation of current robots in healthcare. Some suggested that current capabilities are limited to devices without automation, such as teleoperated devices or nurse-assisting devices that are controlled by a nurse but may have some automated features. However, two roboticists suggested that there may be some robots operating at Level 2 for specialised tasks, where the robot has combined automated functions but the nurse still needs to monitor the environment and make decisions (R1, R3). These opinions were not specific to nursing robots, as no examples were given.

6.4.2. Future Robotic Capability in 10-15 years

During the interviews, there was consensus that replacing nurses with robots within the next 15 years was not a feasible option. However, roboticists suggested that there could be significant improvements in robot capabilities within the next 10 to 15 years, to the level of partial or conditional automation (level 2 or 3) in most applications. One expert predicted that robots would reach:

> "*level three for sure and playing with level four*" (R3.).

One roboticist proposed a possible intermediate step within the next five years and suggested the creation of a robotic assistant designed to aid nurses by providing reminders, monitoring patients' temperature, and selecting medication for administration (R1). Another spoke about collaboration between humans and robots, envisioning a future where they could share a task (R3). Some argued that as robots continue to improve their ability to navigate unstructured environments, their usability will increase. As one person (R2) put it:

> "*Simple, apparently simple physical tasks, e.g., imagine just the mobile robot that will get to a room of a patient and will just bring the food, e.g., and pick some things on the table, move them around, tidy up and leave. So this kind of manual ability, this is what the robotics we call the manipulation in the unstructured environment".*

Roboticist (R4) predicted that technology was likely to become more affordable and durable over the next decade. Another suggested a future focus on creating intelligent sensors and improving machine learning will lead to better decision-making and conversational abilities for robots (R5). He articulated the possibility of developing "*smart buildings*" that utilise speech and computer vision technology to detect falls or prolonged inactivity and alert healthcare professionals when necessary. Such buildings, he envisaged, could serve as both companion robots and sources of information for patients, connecting them to others and providing reassurance through speech recognition systems.

6.5. Theme Four: The challenges of complexity

Complexity was mentioned explicitly or alluded to in descriptions by all of the roboticists. This complexity was primarily related to the environment and to the limitations of robots in being able to perform within what was termed an unstructured environment, but also to the complexity of nursing. Nursing complexity was linked to the assertions that robots cannot substitute for nursing which was mentioned by four roboticists. Table 6.5 illustrates.

Table 6.5. The challenge of complexity

Table: The challenge of complexity				
	The challenge of the unstructured environment	**Boundaries and limitations of robots**	**Complexity of Nursing**	**The challenge of substitution**
Roboticist 1	It is really hard for a robot to understand where things are or to move around in a complex environment and obstacle avoidance is not advanced.	With patient handling the safety implications are high risk, you could hurt a patient	Nursing includes both physical and mental tasks requiring judgements	Robots cannot substitute for a nurse as robots are not very clever but they could act as a nurse assistant and nurses can more effectively perform other tasks
Roboticist 2	Manipulation in an unstructured environment is simple for humans (like making a cup of tea in different environments) but is massively complicated for robots	Robots can assist with lifting but ergonomics is a challenge and they have limited awareness / understanding of what is going on, unlike a human that can notice a nervous patient	Nurses take account of wider contextual things as well as physical things	Very few nursing tasks can be completely automated
Roboticist 3	The hospital itself can be robotised: the problem is much simpler if we create an environment where robots can move within	Robot interaction with humans is not strongest component as the environment moves quickly, Systems are not Certification marked	Nursing is so many different things, it's more patient facing (than surgeons) and not isolated from everything happening	
Roboticist 4	Robots can approach tasks which are well defined operating within fixed hard parameters	Constraints are build into the robotic system through software and hardware, ie stop if danger of collision		AI enabled technology can free up professional time for tasks that need more time or skill
Roboticist 5	We are very far away from robots that can physically manipulate the world in an unstructured environment. Smart environments however, could enable some technology now	The diversity of different situations in the unstructured environment is so huge with millions of edge cases, it is too hard to have autonomy. People can overstate what technology can really do- like self driving cars	Robots do not have common sense knowledge, humans have all sorts of common sense knowledge and fine motor skills. Nursing is very diverse in terms of things nurses do	Robots cannot replace humans but could allow nurses to spend time on interesting, difficult and important things such as the contextual things in human care

6.5.1. The challenge of the unstructured environment

The challenge of the environment was mentioned by all roboticists with consensus that robots may work well within a structured environment where the variables could be controlled. Complexity was described as a '*too hard*' (R5) problem to solve and another (R1) gave the example of what was considered simple by humans such as making a cup of tea in multiple environments with different shaped kettles, cups, teabags etc but these variations were a source of complexity for a robot for example;

> "*what is a simple task for a human is not simple for robots*" (R1).

Another explained the difference between a laboratory environment and the real world;

> "[it is] *really hard for a robot in an open environment to understand where the person is, where the head is, where the other person is, moving around within a complex environment. Robots are very good at doing things in controlled setups*" (R1).

'*Human intelligence*' was differentiated from '*artificial intelligence*' with human intelligence as being defined as '*general purpose intelligence*' which can be applied to multiple situations (R5). Artificial intelligence by contrast was described as specific to the task and context and not easily be transferred (R5). So, whilst humans could transfer this skill of making tea with ease to a different environment such as a hotel room with a different shaped kettle, with different cup, shelf etc, for a robot this is considered an entirely different task (R1). Similarly, one roboticist referred to the variety of types of unmade beds even within a single hospital setting (R5). Both roboticists (R1 and R5) conceded that robots may, eventually be able to perform in unstructured environments, but the problem was further describe;

> "*very, very challenging and unlikely to be overcome in the next 10-15 years*" (R1).

The discussion around 'edge cases' by another roboticist (R5) compared healthcare to the example of self-driving cars and how the number of variables created;

> "*a huge number of unique situations that it wasn't possible to design into a robot*" (R5).

In citing the many millions of permutations that would need to be solved to enable a robot to function autonomously the roboticist labelled these permutations '*edge cases'* and alluded to safety. Giving the example of a self-driving car encountering a child in the road, he described 'edge cases' as the 1% of scenarios that cannot easily be predicted (R5). Envisioning this as problematic to solve, the roboticist argued that this was due to the variety of patient responses and the very long distribution tail of edge cases. Translating this to patient care, the roboticist related;

> "*maybe they don't speak English, they've got something wrong with their elbow, but they got the word wrong and then they're just pointing at it. And then, you know, maybe they're wearing some strange jumper and the robot is supposed to suddenly come in and actually do something with the elbow?*" (R5).

In discussing the various levels of automation, the issue of decision-making and judgment was seen as pivotal to defining the level of autonomy. One roboticist (R1) asserted that it requires a human person to make judgements and commented further on the significant difference between operating autonomously in **certain** situations and autonomous operation in **all** situations.

6.5.2. Boundaries and limitations

Notably, when asked about future capability, each roboticist described capability in terms of what robots could **not** do and referred to limitations in ability and understanding, e.g;

> "*can't do much more than be a receptionist*" (R1) and
>
> "*very limited in ability*" (R2), and
>
> "*the ability to operate in an unstructured environment won't be overcome anytime soon*" (R5).

Whilst roboticists cited examples of fetching and carrying activities of robots they identified the current limitations, e.g. robots needing to follow a path on the floor to ensure safety (R1), or the need for a flat terrain (R3), and more advanced obstacle avoidance (R1). Full autonomy was perceived as a way off yet even within non-patient-contact tasks.

Roboticists also indicated that the ability of robots to provide physical support is limited by their understanding of situations and people;

> *"There is not much they can do because there's not much that they actually understand of what's going on*" (R2).

This issue of safety was also mentioned by two roboticists (R1, R3). Firstly, the nurse's role in ensuring patient safety was described a scenario in which the nurse would need to intervene if a robot was doing something unsafe (R1). Secondly in relation to the robotic design i.e;

> "*without the full sensing system you might crush the patient"* and
>
> *"It's hard, you know, to, …. handle a patient, the safety, implications… that's why it's far from now"* (both R1).

The need to certify a device for use in such an environment was also mentioned (R3).

6.5.3. The Complexity of Nursing

Roboticists made a number of assumptions about the nature of nursing, firstly that the nurse's role was 100% patient contact and more varied and patient-facing than medicine and includes a large element of environmental consideration. In discussing the environment, it was clear that the roboticist was referring to the immediate environment as "*everything that's happening*" (R1). This was differentiated from the surgical (peri-operative environment) of the body cavity "*you need to tie your knots..*" (R1). Whilst medicine is much wider than the surgical interoperative procedure being referred to here, the diversity of nursing practice and the patient-facing nature of nursing was an observation that was discussed in relation to the role of robots.

6.5.4. The Challenge of Substitution

According to one roboticist (R5), in order to substitute for a nurse, a robot must have two hands and arms with six degrees of freedom, stereovision, and the ability to converse with humans. It must also consider various environmental factors. The roboticist labelled this as an

> "*AI dream that would not be feasible in the next 10-15 years*" (R5).

Roboticists postulated that robots would change the future roles of nurses. They suggested that while robots cannot replace nurses, they can perform repetitive tasks and free up nurses to focus on more interesting and skilful tasks (R1, R4, R5). For instance, robots can measure patients' temperature while nurses attend to other duties, increasing efficiency (R1). The importance of human general-purpose intelligence was emphasised (R5). This intelligence was also referred to as the "*scientific challenge of good sense"* (R1).

6.6. Discussion of Roboticist Perspectives

6.6.1. Definition of robots by roboticists

Whilst the roboticists gave varying definitions of what constitutes a robot, they generally agreed on the important components, namely sensors, motors, and computers. The Collins Dictionary's (2022) definition of a robot as;

> "*a machine which is programmed to move and perform certain tasks automatically"*

This was similar to those put forward by roboticists. However, roboticists emphasised the importance of sensing capabilities, in line with Winfield's (2012) definition of:

> "*an artificial device that can sense its environment and act on or in that environment*".

Some roboticists included the ability to move as part of their definition although one roboticist argued that a smart building could be considered a robot (R5). The IEEE proposed a definition that states that a robot is:

> "*an autonomous machine capable of sensing its environment, making decisions based on computations, and performing actions in the real world*" (Guizzo, 2023).

According to Brooks, the Founder and CTO of Rethink Robotics, a washing machine should not be considered a robot as the term "real world" refers to actions outside of the robot itself (Brooks, quoted in Guizzo, 2023). This differed from the explanation given by two of the roboticists in this study, although there was a general consensus that sensors, computers, and motors are the essential components. These components have guided the definition of a robot in Phases 2 and 3 of the study.

6.6.2. Purpose of developing robots

The four reasons proposed by roboticists for developing robots in the nursing field were supported by the literature. The first reason was to save time, as shown in studies such as Agraz *et al*., (2022) and the preferences of nurses expressed in Lee *et al*., (2018)'s study. Automating tedious tasks was also consistent with the broader literature on relieving caregivers of time-consuming duties. The second reason was to improve outcomes, such as the Da Vinci robot whose efficacy has been proven through systematic reviews (Maeso *et al*., 2010; Hinojosa-Gonzalez 2022). Thirdly, robots have been developed to enhance human nursing capabilities (Christoforou *et al.,* 2020; Kato *et al*., 2021; Agraz *et al*., 2022). Fourthly, robots are developed to perform tasks and avoid the transmission of infection (Arthur and Shuhui, 2020; Shen *et al*., 2021). Obayashi and Matsuyama, (2020) reported on the use of robots in a nursing home to monitor patients and alleviate the workload of caregivers, while Schafer, Stewart and Pott (2019) explored the use of teleoperated robots. Although the effectiveness of robots in reducing COVID-19 transmission is yet to be substantiated, the pandemic highlighted the potential of robots in healthcare.

6.6.3. What can robots do now in hospital environments

The taxonomy, developed to enable roboticists to identify current and future robotic capability was well received by the roboticists as a helpful categorisation tool with one exclaiming that it could become the next standard (R1). The taxonomy enabled roboticists to identify the current level of robotic development and suggest how this might advance over the next 10-15 years. Responses suggested a broad consensus of opinion that robots suitable to assist nurses are currently at level 1 or 2 (partial automation) with some specialised robots operating at level 2 or 3, but probably not in nursing.

Roboticist suggestions that social robots could support patients in a hospital setting could also be found in the literature (Liang *et al*., 2018; Jin and Kim, 2020; Hung *et al.,* 2021). When discussing physical support, roboticists primarily referred to the limitations but one mentioned robotic beds which have been in the design phase for more than ten years (Tan, Lu and Wang, 2009). More recently Wang *et al*., (2015) presented the concept of a hospital bed with autonomous navigation to eliminate the issues of patient transfer from bed to bed. Sadly, this paper does not analyse why patients are moved from bed to bed and considerations such as transfer to an imaging or operating table appear not to have been considered. Lifting devices were also mentioned and a number of devices are evaluated in the literature ranging from wearable robots such as the HAL (Hybrid Assisted Limb) suit or RONA (robotic nursing lifting devices (Mukai *et al*., 2010; Ding *et al*., 2014). Whilst some of the wearables are seen as heavy and restrictive by their wearers, the lifting robots RIBA and RoNA offer an extension of the lifting hoist with the advantage (according to the developers) of a humanoid or robotic pet-like face.

There were a range of views on the degree of autonomy and automation of current robots in healthcare. Some experts believed that current capabilities were limited to devices without automation, such as teleoperated devices or nurse-assisting devices that are controlled by a nurse but may have some automated features. These opinions were not specific to nursing robots, as no examples were given. Nonetheless, the so-called ‘nursing robots’ currently in production were not mentioned, including the Tele-Robotic Integrative Nursing Assistant (TRINA) which has no autonomous function, and robotic beds that can convert to wheelchairs or self-turning beds. Some robots, like the robotic phlebotomy machine, may have partial or conditional automation.

6.6.4. What robots can do in next 10-15 years in hospitals

Despite roboticists predicting significant improvements in robot capabilities within the next decade, there was agreement that robotic capability could not replace nurses in the next 15 years. This forecast differs slightly from Tanioka and Locsin's (2017) prediction that by 2040, robots will be able to perform the same tasks as human nurses. However, Tanioka and Locsin’s (2017) earlier prediction that low-level robots that provide some aspects of care autonomously by 2020 had not been met which suggests that the roboticists estimations may be more realistic. Roboticists suggested that within the next five years, it may be possible to introduce a digital assistant to help nurses with reminders, medication administration, and monitoring. However, they were divided on whether robot development would produce more single-function robots or expand the functionality of existing robots to be multifunctional.

The roboticist’s prediction that robotic development will focus on the ability to function in unstructured environments seemed reasonable, although the launch of self-driving cars has experienced multiple delays with McKinsey’s (Deichmann *et al.*, 2023) predicting that only 17-37% of new cars will have autonomous driving features (level 3 and 4) by 2035. However, it's likely that robot autonomy will increase over time. Similarly, the reference to the National Robotarium in Scotland, UK, suggested that smart buildings will become more commonplace in the next decade.

According to the roboticists interviewed, full autonomy for robots in nursing tasks was still a distant possibility, even for non-patient-contact tasks. Again, this contradicted predictions made by Tanioka and Locsin in 2017, who suggested full autonomy by 2040. The complexity of the unstructured nursing environment makes it unlikely that robots will be able to replace nurses '*anytime soon'* (R5), although there was optimism about the potential for robots to assist nurses in their 'tasks'.

It is evident that roboticists viewed nursing as a series of parallel or consecutive tasks which corresponds with the findings of Mudd *et al*., (2020). This could lead to incorrect assumptions about how robots will need to function in order to contribute to nursing. However, the roboticists also discussed robots freeing up nurses' time to undertake tasks where more judgement was required suggesting an understanding of the criticality of professional judgement. The idea of robots providing reminders and speech actions to aid nursing staff could assist nurses with their organisational labour described by Jackson *et al*., (2021). Additionally, the roboticist discussion of autonomy and the notion that decision-making was still the responsibility of the nurse supports assertions by Jackson *et al*., (2021) that cognitive labour is a crucial aspect of nursing practice. This cannot be replaced by the robot in the foreseeable future.

It is clear that further work is needed to enable robot developers to develop meaningful capabilities in robots. During the 2021 interviews, roboticists were cautious regarding the potential for artificial intelligence to achieve "general" intelligence. In contrast, recent media discussions have shifted from "if" to "when" artificial general intelligence will be attainable. Despite such technological advancements, with artificial intelligence attempting to replicate human neural networks by linking vast amounts of data, Fjelland (2020) warned against overestimating the capabilities of technology and underestimating the strengths of human beings. Scholars such as Polyani (2009) also argued that tacit knowledge gained through experience is an essential part of human expertise. Furthermore, Drayfus (1979) suggested that tacit knowledge is a crucial aspect of human intelligence, thus suggesting that human intelligence and artificial intelligence are fundamentally different. This further relegates robots to a supporting role in the nursing profession for some time to come.

6.7. Chapter summary

This chapter initially sought roboticist definitions of a robot and there was broad consensus that a robot could be defined as an electromechanical device that has sensors, actuators (or a motor to move) and a computer. Robots are being developed to automate mundane and repetitive tasks and therefore release professional time, improve outcomes and augment human capacity. This could include lifting, moving and handling and in supporting human dexterity and information processing and data management.

Feedback on a framework of automation for nursing robots found that roboticists considered it a useful framework for further discussions. Currently, robots exist that could be described as level 1-2 (nurse assistance or partial automation) and in the next 10-15 years roboticists predict that this extends to robots at level 2-3 (partial or conditional automation). However, robot autonomy was limited in an unstructured environment due to the many millions of variations and permutations that could occur. There was also consensus that robots would not be able to substitute for nurses in the next 10-15 years but could take on a helpful assistive role. Currently, environments are designed for humans and robots are limited by their sensing capability and understanding. This limits the future role and function of robots to tasks within a very structured environment or within fixed parameters. However smart environments could enable the greater use of robotics and technology.

These results were shared as a high-level summary with the Registered Nurses and their reflections are presented in the next chapter.

Chapter 7: RN perspectives.

7.1. Introduction

Having presented the findings from Phase 1 (Roboticist interviews) this chapter presents the findings drawn from the Phase 2 Registered Nurses focus group /interview data. Firstly the chapter explores perspectives of what robots might do using the Fundamentals of Care framework to discuss the specific nursing activities. Secondly, the chapter considers the 'how' in terms of the roles that a robot might undertake in the future. Thirdly three underpinning themes are presented which may explain some of the 'why' underpinning the RN perspectives.

7.2. The Fundamentals of Care Framework

Each of the registered nurse focus groups invited discussion about the potential for robots to assist with the elements of the Fundamentals of Care (Feo *et al.*, 2017) framework with a focus on the Psychosocial, Physical and Relational dimensions. Participants were asked if "robots could/ should assist" or the "robots could not /should not assist" for each element. A graphical representation of each element (named as Figures 13.1.1. to 13.3.6. in ***Appendix 13***) was created to provide an overview of contributions along a continuum. In placing comments on each continuum consideration was given to strength of feeling, e.g., a contribution that asserts "*definitely not*" would be placed closer to could not/should not end than a comment stating "*perhaps if* …". Where very similar comments were made by different people, not all are included but at least one has been included in the graphical representations. Each graphic gives an overview of the spectrum of data and the level of agreement. Thus, a higher number of arrows clustered towards one end indicates a higher level of agreement, or if arrows are more spaced out along the spectrum this indicates a wider range of viewpoints. These graphical illustrations have been summarised to give an overview of each of the Physical, Psychosocial and Relational dimensions of the FOC framework.

7.2.1. Physical dimension of FOC Framework

Nurses generally favoured the use of robots for physical assistance tasks such as lifting, moving, handling, and mobility. There was broad agreement that robots might assist with patient mobility either by assisting ***nurses*** in their manual handling or by assisting ***patients*** to be more mobile and maintain independence. Exoskeletons to assist patient movement were mentioned positively. Only one participant rejected robots assisting with mobility and the reason for this wasn't given, but others identified the need for human supervision.

There were a range of views on whether robots could assist with personal cleansing and dressing with a number basing their judgements of robots on capability such as;

> "*I don't think they'll be able to help*" (RN 2.1.) or
>
> "*insertion of catheters*" (RN 9.).

One nurse sought to define the parameters further, differentiating between helping a more mobile patient find shoes or clothes, and the personal cleaning of a bed-bound patient, alluding to the increased decision-making required to do this (RN 4.2.). This complexity was mirrored by another who argued that personal cleansing and dressing provided a nursing opportunity to consider skin integrity, implying that robots would not have the capability to do this (RN 1.3.).

Similarly, comments related to patient assessment were made in regard to toileting where nurses considered it acceptable for robots to guide patients towards the toilet but raised doubts about the capability of a robot to deal with more complex situations such as assessment and dealing with diarrhoea (RN 4.2.). Another suggested robotic assistance would be inappropriate because toileting comprised both physical and emotional aspects, the latter which she didn't think a robot could perform (RN 6.2.). There were strong opposing views on how far a robot could assist, with one nurse suggesting that a robot could provide stoma care (RN 8.2.) and another suggesting that due to personal intimacy, patients might prefer robotic assistance (RN 6.1.).

It was evident that as nurses considered each activity, they considered the amount of judgement required. For instance, nurses were supportive of robots delivering food and drinks to patients, particularly drinks at regular intervals with one nurse eloquently envisioning the potential time-saving (RN 8.3.). However, there was considerably less support for robots involvement when greater skill or recognition of risk was needed such as feeding patients or helping them to eat and drink. Many of the nurses cited risks associated with aspiration and the ability to adjust to a patient's need to eat faster or slower which was perceived as beyond the capability of a robot.

Similarly, whilst some nurses could not envisage how robots might assist with rest and sleep, others identified that distraction activities might help the patient to relax and rest. Some RNs suggested that robots might remotely monitor a sleeping patient to assess how a patient is sleeping, or to detect changes (particularly in patients with neurological conditions or at risk of seizures). One participant suggested that a robot may be able to observe more than one patient at a time whereas a human nurse could only monitor one patient (RN 8.2.).

A similar pattern was seen when considering how robots might contribute comfort and nurses were supportive of robots providing comforting words or distraction. This overlapped with other elements such as helping patients to cope and keep calm where generally nurses were supportive of robot assistance. The element of comfort also included pain management and one nurse suggested using robotically guided equipment to cannulate arguing it would be less pain-inducing to the patients. There was however resistance to robots undertaking assessment of pain or making judgments on whether the level of pain was to be expected or not. This was primarily linked to perceived robotic capability and the complexity of assessment.

The safety element of the FOC framework includes the monitoring of vital signs and risk assessments and activities aimed at preventing harm. Nurses generally perceived that robots could assist with patient safety through the recording of vital signs and monitoring of at-risk patients. However, the distinction between taking and recording observations and a fuller patient assessment was discussed in several groups with one nurse implying that robot assistance may cause duplication as the nurse would still need to go and see the patient, even if the robot had recorded the vital signs:

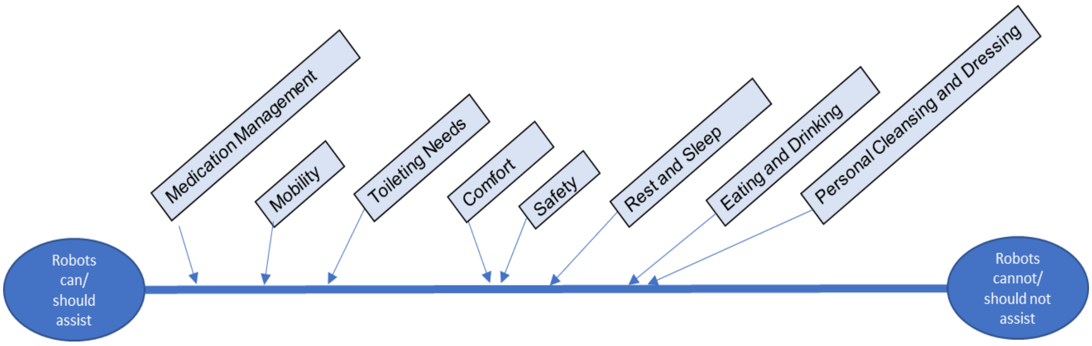
> "*you need to look at the patient as well, so it's still up to you to go and see the patient, so I don't know how helpful it will be actually*?" (RN 2.3.).

Others thought robots could contribute some elements of patient assessment, with one nurse citing 'falls' risk assessment as an activity that could be delegated to the robot (RN 6.2.). Two RNs suggested was that a robot could undertake a skin assessment as part of risk assessment for tissue injury (RN 1.3., RN 2.1.).

Several participants commented that robots could improve safety and reduce errors (e.g. RN 1.1. and 7.4.) and a few cited opportunities for both robotic dispensing and automated robot administration for immunisations and intravenous medication. However, several others identified their discomfort or unease in being able to trust robotic accuracy, preferring to rely on human oversight. One nurse questioned how a robot could follow a detailed electronic algorithm such as confirming if anticoagulant stockings had been removed, which alludes to additional safety checks that have been incorporated into the medication round. Another nurse described how he could adapt, rephrase and simplify information when explaining about medication to help a patient understand their medication. *"A robot won't do this"* he stated, emphasising that there would be something lacking if a robot were to administer the medication (RN 3.).

In general, there was clear support for robots assisting with some physical tasks, as Figure 7.1. illustrates, in particular moving and handling activities, medicines dispensing and activities that provided comfort or distraction for patients. There was, however, much less support for autonomous robots in patient contact activities where there were concerns about potential risks to patient safety.

Figure 7.1. RN perspectives of physical activities robots can assist with



7.2.2. Psychosocial dimension of FOC Framework

This dimension of the FOC Framework included a number of communication activities and most nurses appeared to accept robotic involvement in communication. Nurses were supportive of robots assisting patients to be involved and informed, although limitations were pointed out by some. Specific suggestions were offered, for instance; mimicking a relative's voice to reassure a patient with dementia (RN 9.) or assisting with typing for a patient (RN 8.2.). A number gave examples such as robots reiterating health information, medication details or discharge advice. One nurse hypothesised that that a robot could be "*loaded with* *information*", in order to answer patient questions about 'Green and Red' days (which respectively means days when things happen such as scans, and days when the patient is just waiting). There was enthusiastic consensus that robots could provide information in different and more helpful formats and suggestions were made about how robots could build on that already imparted by professionals such as extra information about medication. This suggests that nurses were supportive of robot involvement when communication was bounded i.e. "*communicate with a plan*" (RN 8.1.) or discrete companion-like activities (e.g., "*having a chat"* RN 3.).

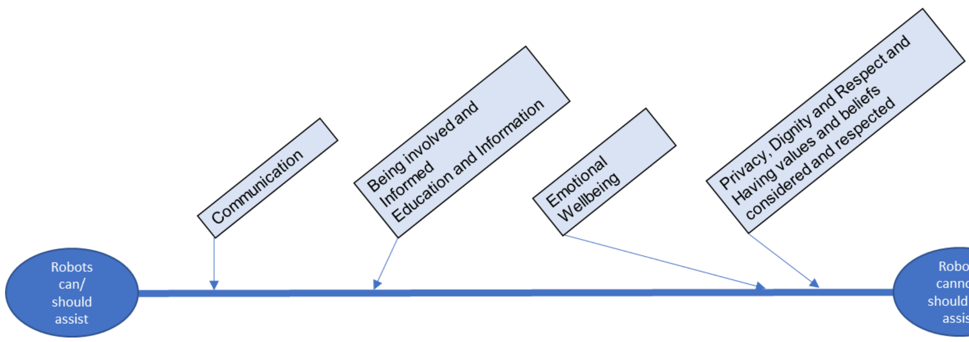
However, there was less agreement that robots could 'educate' (which implies an active and skilled decision-making process and higher level of judgement). Here reference was made to the individuality of patients in both their clinical condition and informational needs. One participant said they didn't think a robot could assist (RN 6.2.) and another (in response to the suggestion about the robot accessing additional information) suggested that the robot might overload the patient with information (RN 1.2.). Whilst there were a couple of dissenting voices, concerns were also voiced about the robot's ability to read facial expressions and non-verbal cues.

The non-verbal aspects of communication also featured in discussions about privacy, dignity, and respect which were frequently linked together with the element of 'Having beliefs and values respected'. Whilst several comments revolved around the ability to programme a robot to be respectful or to maintain the privacy of information, some believed that privacy should remain a human responsibility and not be delegated to robots, suggesting that a robot may not be able to differentiate between what to keep private or not. Others raised the possibility of a robot being hacked, compromising privacy, and one nurse aired concern that a robot fitted with a camera for data collection might violate one's privacy and dignity (RN 2.2).

The ability of the robot to meaningfully assist with emotional well-being was directly related to perceptions of robot's capability to create an emotional connection with patients. One nurse focussed on emotional intelligence stating it was needed for nursing, and robots were unlikely to have it (RN 5.2.) and another relayed critiques that nurses can come across as 'robotic' if they didn't display any emotional connection (RN 6.2.). The exception was argued by one nurse who described technology use contributing to emotional well-being for children (RN 6.2.), although another participant argued that overuse of technology could negatively impact the ability to bond with others (RN 4.2.).

In summary of the psychosocial dimension, opinions were divided regarding robots addressing patients' psychosocial needs as Figure 7.2. illustrates. Most nurses were in favour of robots performing specific, straightforward duties such as conveying information in various languages or relaying messages. However, in terms of respecting patients' values, beliefs, privacy, and dignity, nurses were generally opposed to involving robots, either because they believed such tasks required human skills or because they deemed them beyond the capabilities of robots.

Figure 7.2. RN perspectives of Psychosocial activities robots can assist with



7.2.3. Relational dimension of FOC Framework

Many of the contributions regarding robots engaging with patients, replayed the comments regarding robot ability. Additionally, some participants discussed robot appearance with one participant describing how some dementia patients may be fearful of a robot if it were big or appeared too real like a 'breathing' robotic dog and another recommended a humanoid appearance for relational aspects of care (RN 2.2.).

Activities such as "being present" and "active listening" generated debate about what the terms meant and whether these relational activities were within the capability of a robot. Opinion on robotic assistance was evenly distributed based on assumptions of what active listening meant. Some participants argued that similar technology was already in place, giving examples of digital assistants (e.g. Alexa). Others, however, asserted that active listening required an emotional connection or response, which a machine could not provide. There was general agreement in the few comments that robots would be able to 'be present' for patients, with one nurse talking about how robots may be able to calm and settle a restless patient. Another nurse gave a detailed account of her enjoyment of supporting and being present for patients and her reaction of feeling hurt if this role was to be performed by a robot (RN 1.1.).

Nurses were also mostly positive about robots helping patients to cope and stay calm although some qualified this, mentioning activities such as providing music or diversional games. This mirrors comments made about social engagement, company and support. However, there was considerable reticence about the ability of a robot to support families and carers. Some participants suggested that a robot could assist, but several others argued that a robot would not be able to deal with the complexity of patient conditions and variations in family needs. One nurse argued specifically that it would be impossible for a robot to deal with the complexity of different situations as Robots would not be able to read emotions (RN 5.2.). Another made mention of the relationship aspects of communication, referring to a bond which she implied to be within a human-to-human relationship only (RN 4.2.).

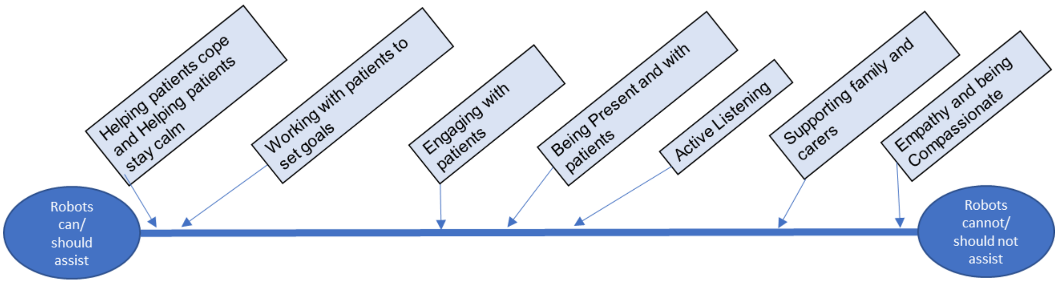
Discussion about whether a robot could be compassionate or not, generated rich debate in each focus group with empathy and compassion used interchangeably. Nurses readily identified the need for compassion in nursing and almost all participants agreed that a robot could not be compassionate.

Both compassion and empathy were variously described as human attributes, built on human experience and comprising an emotional response which could not be replicated by a machine, e.g., one participant argued that both emotions and human experience are a prerequisite for empathy and robots would not have either (RN 3.) However, another participant discussed how a robot could be programmed to recognise human emotion and therefore provide an empathetic response. One nurse suggested that it might be possible to programme compassion into a robot (RN 9.). Furthermore, this nurse argued that there was a big difference between speaking compassionately (which she argued that a robot could do) and acting on the responses. This highlights an important distinction between ***being*** compassionate or empathetic and ***acting*** compassionately or with empathy.

A small number of participants commented specifically on working with patients to set, achieve and evaluate the progression of goals. Comments included suggestions that robots could provide reminders, although two of the participants suggested it would be a significant period until robots could assist with goal setting/evaluation.

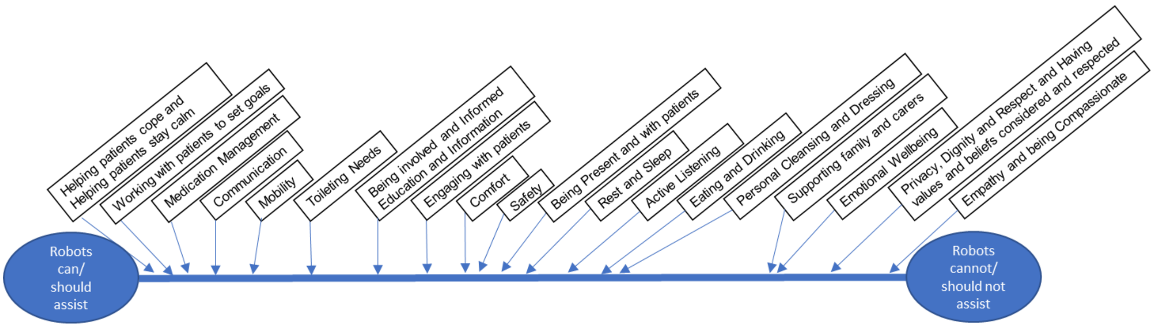
In summary, the relational dimension of the Fundamentals of Care framework refers to the caregiver's actions, and a further polarisation of perspectives was evident across the data as Figure 7.3. illustrates. Robot assistance to engage with, be present, help patients to cope and keep calm was generally welcomed by nurses but there was almost consensus that robots were not able to be empathetic or be compassionate with some advocating that these were uniquely ‘human’ skills.

Figure 7.3. RN perspectives on relational activities robots can assist with



In terms of an overview of the activities robots might undertake in the future there was a range of responses and opinions with nurse participants more readily agreed that robots might assist with physical activities than relational ones. The range of opinion is graphically illustrated in Figure 7.4. below with the activities with the widest range of opinion listed towards the middle of the continuum and those with the strongest consensus towards each pole.

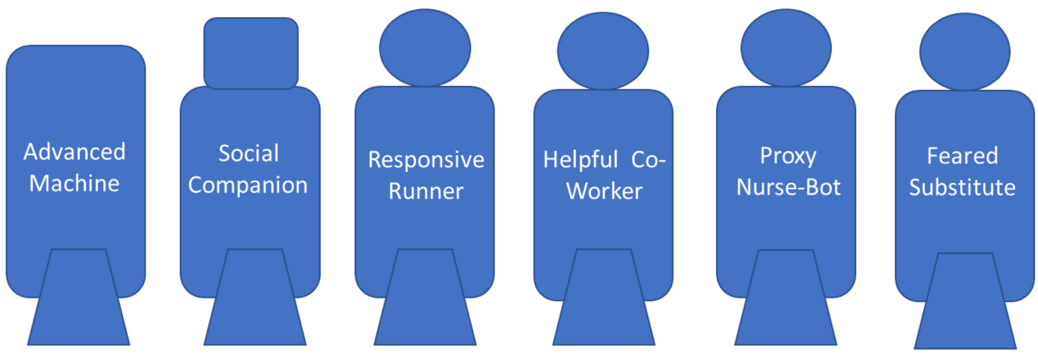
Figure 7.4. Summary of FOC activities that robots can/cannot/should/should not assist with.



7.3. How the robot's roles are perceived

As participants discussed the activities that robots might or might not undertake, they used several different descriptors which referred to **how** robots might undertake these activities. The data were organised into six distinct roles that nurses envisaged robots might undertake as illustrated in Figure 7.5. It should be emphasised that these roles were not suggestions for robots to undertake, but rather concepts created to summarise the nurses' ideas. Each role was given a label to summarise its function and perception. For instance, the 'responsive runner' was assigned to a role responsible for fetching and carrying, such as collecting dressings and delivering them to the nurse at the patient's bedside.

Figure 7.5. Six Robot roles generated from RN data



There was an implied hierarchy to the graphical representation above. The advanced machine, with the lowest level of autonomy, was pictured without a display or 'head' to signify that it is a controlled machine rather than a 'thinking robot'. The roles were then arranged in ascending order to indicate increasing autonomy with the proxy nurse bot and the feared substitute having highest levels of autonomy. However, the responsive runner was described as having more autonomy than the social companion as the social companion's activities were mainly digital and did not require movement. In contrast, the responsive runner role was described as having a higher level of autonomy in terms of movement, grasping, and collecting than the social robot. Thus, although there is some alignment between the robot roles and the six-level taxonomy developed for this study, a single robot role could theoretically be at any of the automation levels.

7.3.1. Role 1: Advanced machine

A number of contributions referred to the robot as a machine requiring operation, maintenance and storage. Nurses described this role as they would a piece of equipment, which nurses needed to be trained to use and then operate under their direct control.

> *"We're dealing with so many machines and computers and everyday basis and definitely, we need to be, it's a complex machine the robot,"* (RN 6.2.)

> "*When again when I look at it, on the other side, I see robots are just like machines*", (RN 3.).

In common with using a machine, comparisons were made with assistive equipment:

> "*so I think the things that they can help with which we've mentioned a bit, which is manual handling: pushing, rolling, moving, feeding even…. it's very physical ….and I'm definitely not saying healthcare systems can be replaced by robots, but some of it could be helped by robots*" (RN 5.2.).

> "*One thing I would dearly love is for robots to help to lift the patients*" (RN 9.).

Another participant pointed out that such assistance would still need to be controlled by the nurse and may not save time but may save physical effort:

> *"But I don't think that so much in time. because, depending on what patient that we try to sit up from a lying position in bed? yes if it is someone who's left limb has to be position in a certain way, or who can only tolerate so you know,*

a certain angle, we still need to be there. So in terms of time I don't think it's going to save that much time but maybe in terms of physical effort yeah because we still have to guide what they're doing" (RN 7.2.).

In this description about the repositioning, the nurse describes the need to guide the robot implying a degree of robot autonomy, but under nurse control. Some nurses described advanced machine capabilities such as a robot titrating intravenous medications, and robot providing automatic vaccination. Both appeared to conceive robots as a more sophisticated version of a pre-existing machine such as the IV infusion pump or an attachment to an ultrasound cannulation device.

As with other equipment, nurses described the importance of training to enable their use of the machine:

> *"I think if we were given proper training in the beginning yeah training and like showing us like the how to operate and everything like that, then we would be more comfortable"* (RN 1.2.).

This was reiterated as a safety requirement by another:

> *"like I said it's more safety really for us and knowing how to use equipment and stuff than just dropping us in the deep end"* (RN 1.3.).

Machines need servicing and nurses mentioned this with one nurse asking if this cost would come from costs saved by implementing robots:

> "*And what happens, you still have again the same humans to service the same machine in order for it to be efficient, efficient, or effective, so I.. It does bother me a little bit more, that is, like cutting down the cost on this side and then applying cost somewhere else",* (RN 3.).

Although not recommending further robotic development, a number of participants pointed out the limitations of machines which in turn suggest limitations to the assistive machine role:

> *"A robot don't have experience, it's just a computer and you just program it to say ABC….yeah and he'll just say what has been put there, they can't change the words, it will just be repeating the same thing, repeating the same thing, repeating the same thing without actually adding to the conversation*" (RN 4.2.).

These insights suggest that the role of the robot as an assistive device was largely accepted as an extension of current technology and was postulated as being helpful, particularly with patient lifting and manual handling tasks.

7.3.2. Role 2: Social Companion

Many of the respondents suggested a role for a robot in direct support of patients acting as a social support for the patient (and occasionally the nurse). This social companionship role encompassed the activities of diversion, translation and companionship and participants likened the functionality to phone or tablet capabilities and digital assistants. Consequently, RN's talked positively about the role that social robots have to play:

> "*The robots are friendly because they come in the form of some sort of a cuddly animal or whatever. They do have a massive role to play. Yes!"* (RN 9.).

Robots acting as social support was envisaged as therapeutic for patients firstly through providing entertainment for the patient and secondly by connecting people. Providing entertainment was described by several participants:

> *"some of the patients….may need some kind of engagement, sometimes, and that may distract from, you know, the things that can trigger them. So yeah,*

> *that….may be done by the robot*" (RN 1.2.) and "*To keep them calm, because .. we have that problem in the HDU, where you have lots of restless, agitated patients, the nurse she doesn't have time to you know*" (RN 4.2.).

These preceding examples refer to robots undertaking a role which was implied to be a delegated part of a nursing responsibility. Similarly, nurses described the robot as an active participant in connecting patients to each other as follows:

> "*take part in games….like four different people, all together, like you know you know, maybe hospital ……we could have a robot and he could play some Bingo and he would just shout out the numbers for them*" (RN 1.1.).

An example of robots connecting patients with their families was suggested by a nurse drawing on her COVID-19 experience:

> "*Like family members not being able to communicate with their,…..nurses not having the capacity to interact with family….. maybe that's something that we could delegate to robots through the video calls and those things that they could see their families, actually speak with them*" (RN 5.2).

Several participants envisioned a robotic role in language translation:

> "*A lot of us nurses, we either speak like two languages, but the robot can be programmed to speak many different language..[..] which will be helpful in communicating with the patients who speak varied languages*" (RN 7.4.).

In summary, the robotic role of social companion was described as providing entertainment, facilitating connections and acting as a translator, and in these aspects the role was perceived as autonomous.

7.3.3. Role 3: Responsive runner

This potential robotic role drew together the tasks of object collection, fetching and carrying. Using the technology of sensing, navigation, grasping and carrying, a robotic role was described whereby the robot responds to commands to find or retrieve objects. This courier-type role was described as responding to ad hoc need such as collecting or delivering. Examples were again drawn from COVID-19 pandemic when nurses found themselves working in full PPE with time-consuming donning and doffing procedures. The need for a 'runner' to retrieve needed items was described:

> "*For example, like if I'm taking care of my patients in my cubicle, just imagine it's closed, cubicle. So I need to get some… dressing material for my patient*" (RN 6.2.).

> "*I mean stocking up a bed space, having water ready, have water boiled with hot water just to wash the patient, but this simple task. Getting medication from the pharmacy because it was loads of running around trying to organise the day which I would have preferred to spend at the bedside, just being at the bedside and someone bringing me everything that I needed*" (RN 4.3.).

Collection from pharmacy was mentioned a number of times across focus groups as was responding to specific patient requests as this example of the taking of the food order illustrates below:

> "*maybe you need a drink or something, instead of raising ringing the buzzer you could press a button that says you just need a drink and then instead of the nurse coming to you, finding out what you want, and then going to get what you want*" (RN 8.2.);

> “..*probably if we have robots we'd need patients that need five cups of tea a day so probably maybe the robots that might be good to go and do those teas and bring them”* (RN 3.).

The potential to save nursing time plus the responsiveness were key features of this role and some nurses also suggested extending this role to include answering call bells and assisting by pushing patient beds or delivering blood samples to the laboratories. This multi-purpose courier or porter-like role appeared to be described as more responsive than the current services hence the terminology of the responsive runner.

7.3.4. Role 4: Assistant Nurse/ Helpful Co-worker

This role description builds on the task allocation of the responsive runner and was perceived as a trained, but not professionally qualified, assistant working alongside registered nurses. One RN characterised the duties as similar to those undertaken by a healthcare assistant or clinical support worker and included administrative duties that directly support the registered nurse:

> ”*Things that often if you're a nurse, you might delegate to a health care assistant and actually the healthcare assistant role is pretty massive and it's very hard work and it's very physical…And I'm definitely not saying healthcare systems can be replaced by robots, but some of it could be helped by robots*” (RN 5.2.).

Another alluded to this by describing the absence of a healthcare assistant (HCA) creating a gap that a robot could fill*:*

> *“I was gonna say like meal times as well, just like something bringing out the meals, because, like a lot of times our meals were delayed and even still now*

..you can get shift with no HCA ….. I think there's little things that will help people" (RN 1.3).

Another participant discussed the administrative focus that might be undertaken:

> *"that's not direct patient care is it but that's still taking what I imagine, is still a huge chunk of nurses' time and …our trust, has just employed band 4's…they're not nurses, but they're band 4 and they're like discharge coordinators and that's essentially….that role to …help the band 5 nurses, that were struggling to do"* (RN 2.4.).

Similarly, some spoke energetically about how robots may assist with administrative tasks in terms of nursing documentation describing the significant time commitment at the end of each shift to document care. The possibility of a robot transcribing nurses' speech directly into the electronic clinical record was postulated as a significant help.

In each of these examples, it is evident that the role was to assist the nurse with the tasks or roles that he/she was unable to complete and this appeared the rationale for considering such a robot role..

7.3.5. Role 5: Proxy Nurse-bot

This potential role was described as high-performing with the capability of undertaking a significant number of nursing activities. It is evident that whilst there was a considerable range of opinions on what a robot could contribute, there was consensus on what it could not – primarily around compassion, empathy and adaptation to individual needs. Therefore, this role brings together descriptions of a robot carrying out similar nursing activities to that of a human registered nurse but conceptualised as '*not quite a real nurse*' or '*a robotic nurse with relational limitations*' i.e. the robot in this role can do most, but not all of a nurses role'.

In terms of the ability to respond to individual needs, this was perceived as an area of distinction between robots and nurses, e.g. taking part in a difficult conversation as one participant argued:

> "*I'd struggle to, I think, almost compute for want of a better word, how we can teach that to robots and in instigating those conversations about death and dying with family and relatives*" (RN 2.4.).

This was reiterated in a less emotive example of interpreting patient reticence:

> "*The person –'do you wish to take your medicines yes or no?' And if you say 'No'. The robot cannot figure out why you are not taking your medicines. It may be you feel sick, it may be you are developing an adverse reaction, and it could be other sources, that is not the right medication, the robot cannot differentiate between these kind of answers*" (RN 9.).

Furthermore, this ability to adapt to a changing patient condition or behaviour was perceived as another differentiator for the robot acting in place of a nurse:

> "*In that, we've got robots can do some functions, but they can't do all functions and they still need management by somebody and safeguards as today a fully integrated, full autonomous robot does not exist*" (RN 9.).

Another differentiator was that of being able to multi-task which is a feature of nursing practice as one participant reported:

> "*Yeah, but I can ….do 10 things at the same time, I can run for water, I can give medication, I can always get to if you need some help around the bed, I can turn off lights, I can do all that may be in a single, two or three minutes, but I don't think a robot is able to do that*" (RN 3.).

Participants gave a number of examples that this 'proxy-nurse robot' could undertake but invariably qualified the description with the limitation for the robot as the next example demonstrates:

> "*maybe the education, information but only in specific circumstances say like someone, you know, like we give out like leaflets for things and the robot could have maybe have a conversation with someone and answer questions about maybe an antibiotic they've been taking or something. But ……again it's about patient choice: would they rather speak to a human or a robot? I feel like most people probably rather speak to a human*" (RN 2.3.).

The shortfalls of such a robot role were discussed by most participants and the consensus around robot's inability to demonstrate empathy, compassion and understanding, underpinned descriptions of a robot version of a nurse as being in some respects, substandard. Some related this gap in understanding to deficits in observation and interpretation suggesting that the ability to differentiate between emotions was a human-only capability:

> "*there are things that humans, that as nurses, we're human, we can capture about our patients, like maybe the facial expression of pain or a patient who is not able to express themselves so, how will the robot be able to pick up you know those things that we see and, and how am I going to say, and interpret that it is pain or joy or discomfort, how would they be able to pick that up?"* (RN 7.2.).

Another RN argued that it was the therapeutic nature of the two-way relationship between patient and nurse that was not replicable by a robot:

> "*Yes…… this is part of our, our day to day job. You're actually seeing somebody's expression, your face, your body language and all that actually it's*

> *therapeutic when you're beside your patient and they feel much comfortable, there's much assurance around that than a machine would, and I don't think really it's going to show there's no empathy or smile …….And you being a patient lying in bed, you know that what performs the work that's a machine, you know that that's not a human, so it's It can never It can never be the same*" (RN 3.).

Quoting Maya Angelou, one participant argued that a key attribute of human nurses was the ability to convey feeling and to help patients feel:

> "*All of those things- they'll forget you, but they won't forget that feeling, and those are things that you, only a person can convey and, in fact, not many people can convey that! I think very special people, so certainly not a robot!*" (RN 5.2.).

Others went beyond sentience, with one nurse suggesting a more spiritual deficit:

> "*I presume robots will be able to socially interact with humans, but to emotionally connect with humans would be, yeah something that a lack with robots, robots. And I think that that is something that is not achievable, that is something you can only have if you have a soul*" (RN 7.6.).

Similar attitudes were referred to when the concept of human touch was discussed across focus groups and participants pointed out that this consisted of more than physical touch:

> "*no- emotional as well, emotional and physical, yeah it's the feeling, isn't it like …..how you make someone feel like?*" (RN 1.1.).

This importance was laboured by others (RN 1.3. and RN 4.3.). Discussions clearly stated that this differentiated nurses from robots:

"*that makes us being a human, that's why we are not robots are we?*" (RN 1.1.)

Interestingly these absent robotic capabilities of feeling, compassion and empathy were seen by two nurses as an advantage that the robot may have over the human nurse. The absence of feeling would mean that the robot would not be upset by human behaviour such as shouting (RN 6.1.). Therefore, the perceived robot role of proxy-nurse bot is seen as a partial nurse substitute but clearly differentiated from a human nurse by its deficits. These include a single or consecutive task orientation and an inability to demonstrate some key aspects of nursing authentically – hence the term proxy nurse-bot.

7.3.6. Role 6: Feared Substitute

This characterisation was largely similar to that of the proxy nurse-bot but this robot role encapsulated descriptions of fear and discomfort. The source of fear appeared to be closely linked to a fear of substitution, but descriptions encompassed the fear that robots might take over or usurp the role of the nurse as this example illustrates:

"*oh my God is it going to be like one of those, where it's like the end of the world and it's just robots?*" (RN 1.3.)

A number of nurses also cited a malevolent fear that the robot may take over or act inappropriately:

"*human beings know good from bad, and can make judgement regarding what benefits us and what doesn't. Robots don't know what is good from bad, it only does what you tell them, what the programme does, and what if? Well, we hear about robots that causes havoc you know in industry and all that things*" (RN 9.).

A more extreme scenario was described where robots outnumbered nurses and turned against nurses:

"Because what if they all turn against us? What's gonna happen? you don't know, they might just fail but something's just gonna you know go wrong in the system, and they will just like I don't know block the entrance or we'll just do something wrong and then you're outnumbered and then just who's going to help you, I'm in like you know that it's just like science fiction kind of a scenario, but you know, I wouldn't like to be outnumbered by them yeah. As long as it's not gonna, they're not gonna overtake us!" (RN 1.1.).

Others referred to malfunction perpetrated by humans by hacking into the robot:

"…someone can hack into the system and cause mayhem that's what I'm thinking" (RN 4.1.);

"the other thing I would worry about things like hacking. What if it is hacked and then doesn't do what I want it to do anymore, and then, what do I do, then?" (RN 8.2.).

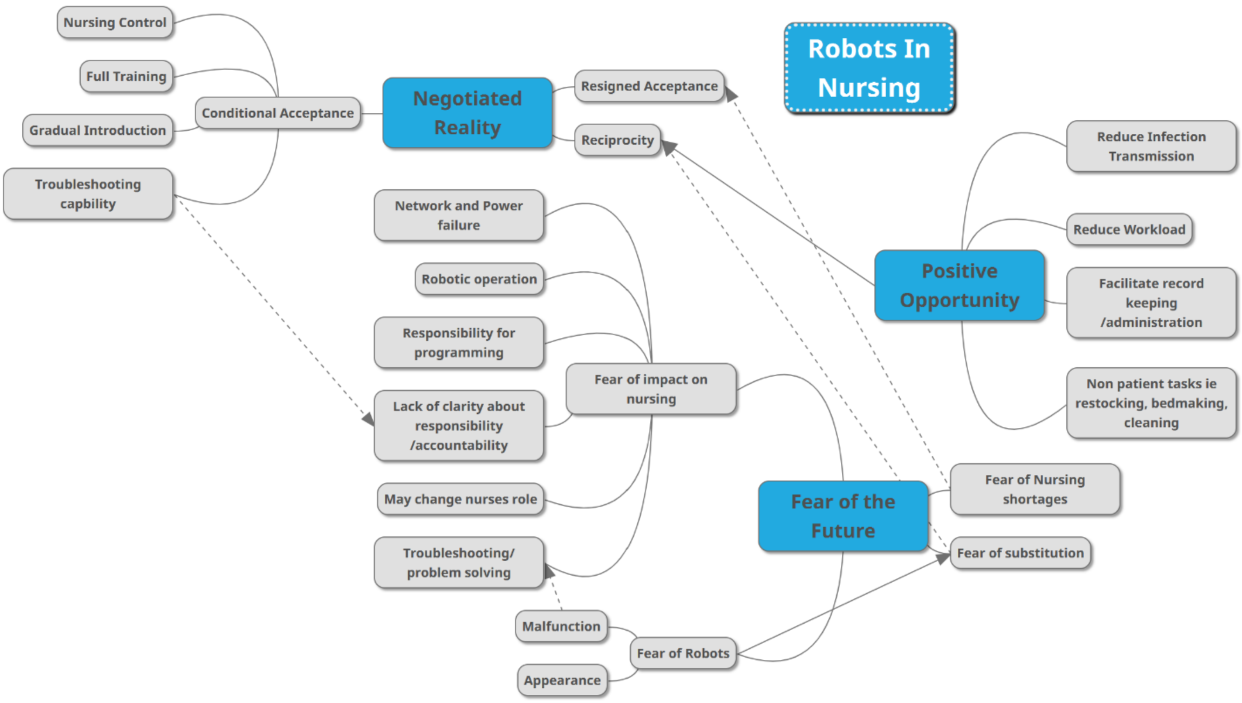
This 'robot role' was not one that was recommended but rather a pattern in the data that warranted reporting. Notably, many of the nurses' concerns revolved around a belief that robots would lack the capability to contribute. In contrast, this role originates from a belief that robots **would** have nursing capability and act as a nurse substitute.

Each of the first four roles were conceived to work under the direction and control of a nurse, with the last two having a high level of automation and autonomy. These roles were generated from reflective thematic analysis of the RN focus group/ interview data. As the data was analysed, several cross-cutting themes were evident which might explain nurses' perceptions further. These are presented next.

7.4. Concern and opportunity: How robots might impact on future nursing.

As nurses discussed the activities and roles that robots might undertake, patterns were evident in the way nurses described their perspectives which provided further insight into their rationale and latent thinking around the topic. These are presented as three discrete themes, which represent the underpinning perspectives which appear to be driving the responses of the nurse participants. These are illustrated in Figure 7.6.

Figure 7.6. Mind map of Themes/ Subthemes from Registered Nurse data.



The first theme is fear of the future, drawn from descriptions of concern of an unpleasant or undesired future of nursing shortages, fear of robots, fear of the impact of robots on nursing and fear of substitution. The second theme is negotiated reality, where the use of robots is accepted as a future reality, but with different levels of enthusiasm based on perception of benefit. The third theme is positivity, where future opportunity is envisaged. Each theme will now be discussed in turn.

7.4.1. Theme One: Fear of the Future

This theme fits with the dictionary definition of 'fear' (Cambridge Dictionary 2023) as a '*recognition or perception of threat or danger'* and this theme has four facets: the impact of workforce shortages; fear of robots, their appearance and risk of malfunction; fear that nursing will change as a result of robot introduction; and fear of substitution by robots.

7.4.1.1. Subtheme: Fear of Nursing Shortages

Most nurses' responses implicitly or explicitly alluded to concerns about workforce shortfalls in the future and most focus groups specifically referred to current staff shortages. Participants either cited the numerical shortfalls in nurses on duty or described the impact, for example one nurse compared nurses to headless chickens,

> "*the nurses are just like running like chicken heads, here and there, they're like doing multi-taskings*" (RN 1.2.).

This fear of shortages was cited by many as the reason that technology or robots need to be considered:

> "*But the thing is as nurses, we cannot fill our jobs*" (RN 8.1.);
>
> *"I think there will be some kind of technology just to assist us because, obviously, we always short of staff*" (RN 1.1.).

7.4.1.2. Subtheme: Fear of Robots

A number of participants voiced fears and anxieties about robots which appeared to be related to either appearance, or the possibility of malfunction. Several participants talked about the robot appearance inferring fear on behalf of the patient, e.g.:

> "*a big piece of clumsy machinery which we fear….That's the thing you see; if there is a big clunk of a machine, oh it gives a sense of insecurity and threatening*" (RN 9.).

Whilst fear may have been linked to size, reference to 'big clunk' suggested that movement and appearance of a robot could also generate fear. It was clear from some of the discussions that whilst nurses tried to anticipate patient reactions, these were entwined with their own reactions as nurses. Take the following example from the same nurse who starts by articulating fear on behalf of the patient and concludes with a more personal viewpoint:

> "*I think you'd have to be really careful where you put robots because I think it could, I mean it will make me nervous seeing a robot coming towards me. Because I would, I would think that that's designed to do one task, but actually is it able to again consent from me? is it able to have that compassion, you know. Is it going to be able to do what a human can do? That would be what worries me, I wouldn't be able to, I wouldn't feel comfortable interacting with it like I would do with another person, but that's how I would feel*" (RN 2.2).

Similar sentiments were expressed by nurses in other groups when discussing the different levels of robotic autonomy:

> "*the first three look fine [no automation to partial automation] and then the last three [conditional automation to full automation], look a little bit terrifying to me. I think terrified, terrified yeah*" (RN 5.2.);

> "*Futuristic, [referring to high automation and full automation] maybe those are the ones that <laughing loudly> I would be more worried about*" (RN 7.4.).

This was an important finding as it suggests that fear may increase as robot autonomy increases. This may be linked to the level of nursing control which diminishes as the robot becomes more autonomous.

It was notable that when nurses described fear of robots from a patient perspective it was more often from an appearance perspective, whereas they described their own fears of robots from an operational perspective. This involved questioning how nurses would be able to learn the complexity of robotic operation with one participant giving the example of how nurses tended to ignore alarms in faulty equipment because they hadn't learned how to troubleshoot the issues (RN 3.).

Another key reason for fear related to concerns about robotic malfunction which featured in a number of the nurse's explanations as these examples illustrate:

> "*So that's, that's my biggest fear and how safe is it? That someone is operating these robots, that how fool-proof is the system there?*" (RN 4.1.).

> "*you've got person suspended in the arms of a robot which means you need to get them out of that somehow, which I think is more dangerous to me than having done it in the first place, with whatever instruments and equipment that we have*" (RN 5.2.).

Fear of malfunction was not limited to the physical function of the robot, the same nurse flagged concern regarding robotic interpretation of a task:

> "*I'm imagining ….how you get it to do those functions so, for example, do you do talk to it and they listen to you and processes and does that action, if it mishears you so, for example I don't know if I say 'go and lift up bed 36', does that robot understand go and lift up the patient in bed 36? or go and lift up the bed in 36 for example? I'm just imagining all these horrendous things going*

> *wrong, because the robot is a robot, so this is trained to hear and process, it's not got a brain*" (RN 5.2.).

One nurse suggested that fear originated from perceived difficulties in responding to situations of robotic breakdown, firstly in terms of getting it fixed. Nurses cited recent difficulties in electronic clinical record dysfunction and the challenge of accessing technical support and highlighted the potential gap left in nursing support in the case of robot breakdown:

> "*I think the fear factor lies in not operating that robot, but what if something goes wrong? […] It's not like in normal life where if can't do that job I'm lost or stumble across something I can't do. Along comes matron and I ask Matron, 'can you help - how do I do this?' and then the problem is solved! But with robots, if things go wrong….you have to know how to solve the problem. I think this is what is putting a lot of staff off embracing automated robot nurses"* (RN 9.).

This issue of robot breakdown raised concerns about how a robot would be replaced if out of service:

> "*What happens if say, the robots become dysfunctional and they have to go for services, are there more robots to come and do that, or will we have to re-employ […]*. *If a nurse doesn't come to work, I call the Bank to ask if I can have a replacement, now if a robot goes off, what is it that you have to call, human or call a robot to come into replace?" (RN 3.).*

7.4.1.3. Subtheme: Fear of impact on Nursing practice

The potential impact of robotic use on nursing practice also generated concerns which were elucidated as barriers to robotic use, summarised in Table 7.8.

Table 7.8. Barriers to Robotic use in Nursing Practice

Table: Barriers to Robotic use in Nursing practice	
Barrier	**Quotes**
Network and power failures	"So power failures, network failures all of those sorts of connectivity things I think would be one big issue". RN 5.2.
Robotic Operation	"And I guess you need somebody to work the robot so you'd need to train people and how to do that, that would be another big section". RN 5.2. "I'm just thinking like how we gonna operate, How we .. gonna ask for the assistance". RN 1.2. "Then, using a robot manual because of maybe how to handle a robot...the manual of the robot will be difficult sometimes, they will be sophisticated and quite difficult for nurses to understand". RN 8.3.
Problem solving of robotic operation	"Maybe the understanding of the working of the robots would be sometimes be difficult for the nurses to manage with." RN 8.3. "It's not like in normal life… you have to know how to solve the problem. I think this is what is putting alot of staff off embracing automated robot nurses" RN 9.
Responsibility for programming the robot	"And sometimes…by the time I tell the robot something ….to do some task for me it's better that I will go and do that". RN 8.3. "We need to find people, clever people who can write a set of programmes to include everything". RN 9.
Lack of clarity about responsibility and accountability	"Who's responsible for them.. like who.. takes responsibility for them if they're doing things like patient cares or if they're doing things like taking blood pressures?" RN 2.4. "What happens if it becomes so dysfunctional that… he has to hurt a patient? Who is accountable for that? Who is going to be responsible, that is it the nurses or it is the manufacturer or how you're going to hold the robot accountable for that?" RN 3.
Robotic use may change nurses jobs	"Moving further into robots worries me more because I think we're already losing essential nursing skills like compassion, and the ability to look at people as people, already… Which would actually having robots make that worse?" RN 2.2.

A number of concerns revolved around the additional responsibility for the robot which ranged from programming and troubleshooting problems through to a fear of being blamed for dysfunction exemplified by questions and comments about accountability for robotic use. Nurses also expressed concern about the additional time commitment, loss of competency or job elements that they enjoyed. One nurse postulated robotic help might be a hindrance:

> "*…by the time I do something on the robot to do some task for me it's better that I will go and do that and so sometimes that can be also different that can also be a barrier for me, that can be also a hindrance for the nurses*" (RN 8.3).

Several nurses cited concerns about the impact on their roles either by removing the elements they enjoyed (RN 1.1.) or deskilling nurses further e.g:

> "*moving further into robots worries me more because I think we're already losing essential nursing skills like compassion, and the ability to look at people as people, already…..would actually having robots make that worse? …….and it does worry me a little bit. Technology isn't always the way forward.*" (RN.2.2).

Another suggested that nurses' fear of using technology might increase nursing turnover:

> *"it might cause more people to leave or not feel comfortable like, working anymore, which again will make some things worse"* (RN 2.3.).

7.4.1.4. Subtheme: Fear of substitution

This subtheme coalesced nurses' fear that robots would replace them and they might consequently lose their jobs, face redundancy or obsolescence. This was discussed or commented upon in each focus group and interview e.g:

> "*And my fear is we are going there again, robots replacing humans <sounds despondent>. I actually fear that*". (RN 4.1.)

> "*[the] issue would be that robots in nursing would do nurses out of a job you know*" (RN 6.1.).

These concerns appeared exacerbated by a fear of unemployment for nurses and others with one participant suggesting that robots might lead to mass unemployment (RN 4.2.). Others were more sanguine, suggesting that substitution might take place over a longer time frame:

> "*but I don't know whether later because of developing technologies, and IT, we don't know like whether later, maybe in maybe 40 to 50 years, maybe, maybe nurse can be completely replaced by, by the robots, so I would say that that can be one of the disadvantages for nurses*" (RN 8.3).

Even ostensibly positive statements about robotic contribution also signalled a latent fear for the future e.g:

> "*Robots to begin with do not fill our jobs, in fact they enhance what we are doing"* (RN 9.);
>
> "*nurses would still have a big role for the next couple of decades"* (RN 1.3.),

The phrase '*to begin with'* and the limitation of two decades implicitly suggested that the situation might change in the future.

Although some tempered the fears with assertions that a substitution scenario was unlikely to occur, it was clear that this was an underlying fear and an active concern in nurse's reactions. One nurse explained this:

> "*But I think I'd be a bit sceptical first because I don't know if my job is at risk, even though there's assurances that my job is not at risk, they still at the back of your mind you are still thinking well am I training this robot to then take over my role, that would be my first concern"* (RN 8.2).

This is important as this fear of substitution may drive scepticism and an unwillingness to work with robots.

7.4.2. Theme Two: Negotiated Reality

This theme was drawn together from responses that implied that whilst robotic assistance might be acceptable, participants had different levels of enthusiasm towards this prospect. Some nurses proffered a resigned acceptance, characterised by the notion that robots will be an inevitable reality to be passively accepted. The second pattern indicated more of a reciprocal negotiated response often using phrases such as 'if…then' and arguing that robots must be considered in order to address the unsolvable workforce challenge. This theme clearly underpinned a number of the robotic roles articulated in the last chapter with the exception of the Feared Substitute.

7.4.2.1. Subtheme: Resigned acceptance

It was evident from participant responses that despite the reality of future nursing shortages, there was a strong element of resignation in considering robot involvement. This was variously articulated with an explicit preference not to consider this if the shortages did not materialise, perhaps best encapsulated as follows:

> "*But we don't have enough people doing the job, and I think this is going to get worse, with time, so I feel that if robots have let's say can help with simple tasks*" (RN 4.3).

During this exchange, the participant held her head on one side with an expression of resigned acceptance and two other participants nodded their agreement. Often the need to consider the role of robots was justified or rationalised by assertions that nursing shortages were not likely to improve and may worsen. Such assertions were stated in a tone of resigned acceptance rather than positive opportunity.

This resigned acceptance was also apparent in passive responses and contrasted with the intensity of assertion to other issues such as robots and empathy. Given that some nurses were so categorical about what was right for patients, it was surprising that a resigned acceptance of a perceived inevitability was also seen in the data.

At their most passive, some nurses answered with counter-questions about what robots could contribute, without suggesting what the minimum requirements could be. Others cited robot capability constraints to suggest why robots should not contribute (rather than suggest what human nurses should contribute or contribute more effectively). Some nurses discussed their personal reservations but didn't identify how such perspectives were worthy of wider consideration, hence their comments were somewhat passive in their impact. It was notable that some of these were phrased around robotic capability. This implied that in order to persuade nurses, nurses simply need someone else to decide, which again suggested passivity. Similar passivity was seen when the issue of malfunction was discussed where it was suggested that the nurse might need to be more vigilant, rather than the robot needing to be more foolproof. Passivity was also evident when participants referred to decisions being made by others or implying a decision having already been made:

> *"I think we are way on the road to having half our workload transferred to robots"* (RN 9.).

Others specifically referred to 'they' or 'you' when describing the decision makers thereby alluding to someone other than themselves. Again, this may have been because front-line nurses were rarely part of the procurement decision-making process, but the sense that these statements gave was that both the purchase **and** deployment of robots would be decided by someone else. This was illustrated in the following contribution:

> *"I think you'd have to, you'd have to run it very, very carefully and the other thing, It's all well and good, saying 'let's have these robots on the ward', actually is a space for these robots? because my ward environment areas can be very small, my IV room is not that big, my nurse's station is not that big"* (RN 2.2.).

The use of "*you'd*" in this quote was notable given that this participant was being quite forceful about her own feelings, yet she was still suggesting that someone else would make the decision to deploy a robot. This was in stark contrast to the use of the possessive word "*my*" when describing her ward and implied that she saw the decision to use robots on a ward as outside her control, whereas where to store a robot might be her responsibility. This characterised a resigned acceptance of the decision-making of others.

7.4.2.2. Sub-theme: Reciprocity

A number of responses across all focus groups and interviews included a reciprocal perspective suggesting that if certain aspects or criteria were in place then robotic involvement would be accepted, for example:

> "*so if there was a robot you probably assign it to them and do other jobs*" (RN 7.5).

> "*okay, we have the robots we use to advance care, to help us in care and…I as a nurse can focus more on ..like more managerial stuff or something that in terms of communication, medications and stuff on that and not on physical, too many physical aspects of care*" (RN 4.2.).

These "if-then" examples were characterised by the assertion that if a robot undertook one activity the nurse would be free to do something else. This reciprocity was strongly predicated on one or more conditions. In the following example the word 'if' was used multiple times which suggested multiple conditions for acceptance including immobility and patient inability to read or understand:

> "*I guess there's a place for that in certain situations, but I'm thinking about the way that information is given at the moment. And it's ..generally in a written form like a leaflet, for example if you've, if you've broken your leg and you've got a leaflet about crutches and casts, it may be more helpful and actually helpful if on the inclusivity side, if you're, if you can't read, if you got sight problems, it might, it might actually be helpful in those sorts of situations to*

> *have a robot who can explain things to you or show you something on a TV screen where it's visual and you understand that better than if someone gives you a piece of paper with some writing that you didn't understand, or maybe a robot who can translate? That would be very helpful*" (RN 5.2.).

This suggested that only 'if' the conditions were met, would the robot be considered helpful. On one hand, this was not surprising, the same might apply to any piece of equipment or indeed another member of staff. However, the number of conditions indicated the degree of reciprocity at play in the discussions.

Others were less specific about the activities that robots might enable them to do but talked in detail about time-consuming aspects of care that a robot might undertake to save time. Core to these discussions was the belief that nurses might benefit in some way from the use of robots, but in order to do so they would have to give something up. This something might be an activity that they don't value or is time-consuming such as getting drinks and food for patients or something more simple such as taking and forwarding messages. It could also link to a different way of doing something i.e. using a robot to attend a patient's bedside (giving up a face-to-face interaction) might protect nurses from infection. This positive opportunity will be further explored in theme three.

7.4.2.3. Sub-theme: a conditional acceptance

For some participants, there was a stronger acceptance of robots in nursing, albeit still heavily predicated on a number of criteria. These criteria were proposed almost as conditional or as prerequisites for acceptance: maintaining control; full training; gradual introduction and troubleshooting procedures. These will now be discussed in turn.

Pre-requisite One: Nursing control of robots

The requirement for control of robots was cited across every focus group and interview. Control was often cited as a strong pre-requisite to the use of robots as these participants explained:

> "*Because I want to be on the safe side, if I leave yeah, if I let… if I allow the robots to take over then and I don't have the control, how do I know that the robot is safe for the patient I'm looking after? That's why it's important for me to still have the control over the robot so I'm seeing a robot as my assistant, yeah for me too yeah in, especially when it comes to physical work, but I would like to be able to tell the robot what to do and what to help me with*" (RN 4.3.);

> "*I feel that the having a human control over the robots is a very good idea, because […]things can go wrong because it's the robots are in total control, so it was always good that human power, human control is there, especially for decision making things as well*" (RN 8.3.).

Both these contributions argued the need for control from the position of patient safety, and both identified the need for human decision making. Control of robots was therefore a prerequisite condition by some for the acceptance of robots.

Prerequisite Two: Troubleshooting and downtime procedures

A strong subtheme was the possibility of robotic breakdown or malfunction and nurses talked about the need for arrangements to be in place to anticipate and deal with such an eventuality. It follows then, that troubleshooting and downtime procedures would be seen as very important as these examples illustrate:

> "*to troubleshoot the robot so if something goes wrong, we could troubleshoot the robot*" (RN 4.2.);

> "*because they [nurses] are already stressed, and they can't really don't feel they have the time to sort it out? […] we just need to have something in place in case the robot would, you know malfunctions, what can we do?*" (RN 4.3.).

Prerequisite Three: Training

Training is often seen as an enabler for technology adoption but participants qualified their expectations describing the necessity for either 'continuous', 'proper', 'full' or 'significant' training. The strength of feeling in the language also conveyed its prerequisite importance as illustrated below:

> "*slowly bringing in step at a time, gradually that training and stuff, and continuous training, not just a one-off and you get on with it!*" (RN 1.3.);

> "*I think if we were given proper training in the beginning yeah training and like showing us like the how to operate and everything like that, then we would be more comfortable*" (RN 1.2.);

> "*I think the full education is necessary, people need to be talked through this in advance, well, ahead so that they start you start preparing… them that this is what we're going to have eventually than just throwing them into the deep end. They will not understand*" (RN 3.);

> "*it would be a significant sort of training process*" (RN 6.1.);

> *"it's a complex machine the robot, it got everything there, so we need to be well trained and it takes time and we don't know how challenging it will be!*" (RN 6.2.).

The language above was assertive including phrases such as 'we need' and contrasting with previous initiatives such as 'one off' and 'deep-end' which suggested that comprehensive and on-going training was more of a pre-requisite than an enabler.

Prerequisite Four: Gradual Introduction and re-assurance about the future

The need for a gradual introduction of robots was cited by several participants and was linked to the need for staff (and patients) to get used to robots:

> "*Slowly convincing people that a robot is a good thing to have which, if anything, if they're anything like me might take some time!*" (RN 5.2.);

> "*I was gonna say just introduce it gradually other than just kind of throwing it in there….it'll be easier for us to be open. And so, patients as well and relatives. It would be more reassuring*" (RN 1.3.).

Importantly one participant asserted that the training related to robotic introduction should commence in nurse education:

> "*I think if, if we're implementing something new in the future for nursing it should also start from the beginning, from the people who are undergrads or people were doing masters, have never done a nursing course before*" (RN 8.2.)

This gradual introduction was also linked to reassurance about the future, which several participants picked up. Therefore, reassurance about not being replaced by robots might also be a key prerequisite for acceptance as it would directly addresses fears about workforce issues and job security.

Again, whilst these aspects of control, troubleshooting procedures, training and gradual introduction could be considered enablers, the description of importance suggested that they are prerequisites for robotic introduction.

7.3.3. Theme Three: Positive Opportunity

Whilst some nurses were fearful or reticent of the future, others described robots as a positive opportunity. Several nurses described excitement at the possibility of robots in nursing and others described the opportunity as fascinating or interesting as these quotes illustrate:

> *"I was really excited, I thought wow, that is really interesting"* (RN 1.1.);

> *"it's fascinating and interesting because, in this age of a robot, we've been like introduced to robots in most of our daily lives"* (RN 7.3.).

Many of the positive comments related to how robots might help nurses and several comments were made about how robots could avoid transmission of infection (as they couldn't contract infection or pass it to others). In addition, a number of suggestions were made that did not specifically relate to patient care including bedmaking, housekeeping tasks, re-stocking equipment and disposables, moving and handling things (rather than patients), information sharing and recordkeeping. A number of participants mentioned record keeping and in one focus group participants had a detailed discussion about the opportunity for robot assistance in downloading speech directly into the electronic patient record system (Lorenzo) as the quote below illustrates.

> *"maybe voice notes, instead of writing or typing in your hand, 'cause some trust, like our trust, with just transition to typing on notes on, on to Lorenzo and maybe you know you speak your notes into the robot and then he takes it down and then anyone can access whatever you said, they'll be so handy with my note taking"* <laughs> (RN 8.2.) <Participant RN 8.3 laughing and nodding>.

As the discussion continued, the note-taking role was explored and nurses clearly thought that the mobile nature of the robot would be more helpful than the nurse going to the computer to access the software functionality:

> *"I just wish that there was, there would be a robot along with us, so that it would just find out what all that we are doing and then just put up instead of us saying our notes, they could just automatically just grasp like what we are doing, and then they could just make a note by themselves"* <laughing> (RN 8.3.) <Participant RN 8.2. makes thumbs-up sign>.

For others, the positivity was seen in the manner in which robotic involvement was described as this quote illustrates:

> *"They [robots] are also very efficient and they are clean and I don't think there is anyone allergic to robots"* (RN 9.);

> *"I would definitely love having a robot with us because that can help us in many of the tasks that we can, that we nurses usually do."* (RN 8.3.).

It was clear that some nurses amended their perspectives during the course of the discussion. Comments such as *"I'm very open to it now"* (RN 1.3.), suggested that this was a change towards being more positive. One participant who started the conversation declaring that she completely disagreed:

> *"Can I take part, even if I completely disagree about robots and nursing? And yeah I still, I still feel the same, I feel like it would be awful"* (RN 5.2.).

Towards the end of the focus group, the same nurse commented:

> *"If it was just we were inventing some robots that can help you with these manual tasks, yeah. I would, I would embrace that because it's going to make my job easier and be able to do a better job, then great"* (RN 5.2.).

In summary, several nurses in each focus group spoke positively about the introduction of robots and the positive opportunities they could offer.

7.5. Chapter Summary

This chapter presented the perceptions of Registered Nurses about the activities, and roles that robots might undertake and found that nurses would accept robots undertaking assistive activities providing that activities and role do not require the use of nursing judgment and constitute a low risk to safety These perspectives were underpinned by an enduring fear of the future which results from concerns about future nursing shortages, robot appearance and malfunction, the impact on nursing practice and potential robot substitution for nurses. In the light of these conflicting fears, the theme of 'Negotiated Reality' related to different levels of acceptance and concern ranging from nurses believing that they have little choice; through to a reciprocal relationship or a conditional acceptance of robots as a future reality, linked to certain prerequisites being in place before their introduction.

The 'Positive Opportunity' theme captured the many positive comments about robots and identified that nurses would value robotic assistance with record-keeping and information-sharing responsibilities.

The activities and roles were shared with the Nurse Leaders and the findings from their Focus Groups are shared in the following chapter.

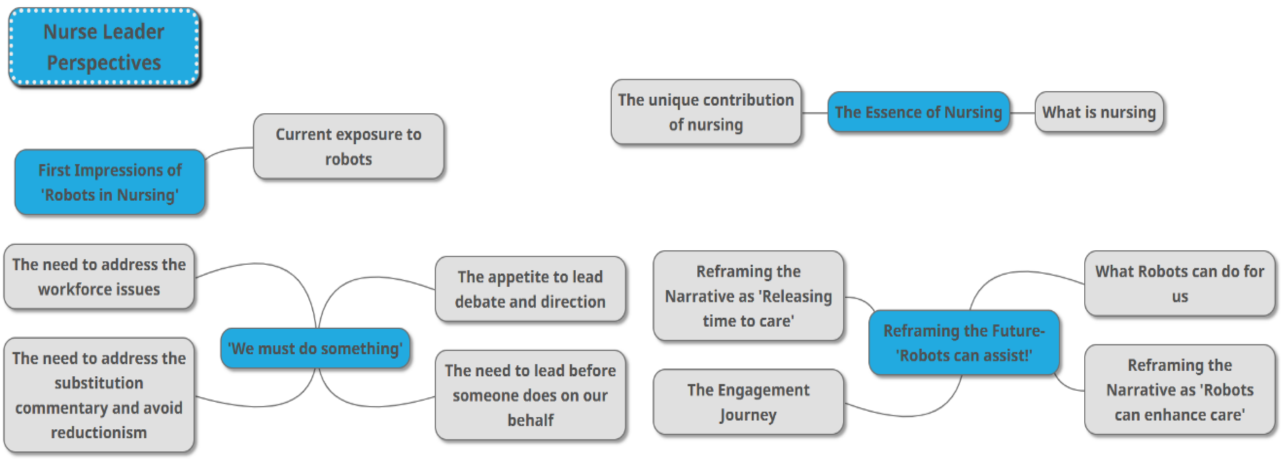
Chapter 8: Nurse Leader Perspectives

8.1. Introduction to Chapter

This chapter presents the results of the four focus groups with Chief Nurses and thought leaders (Nurse Leaders). These focus groups were conducted online as described in Chapter 6 and included discussion of the Roboticist and RN results. Data were thematically analysed and this chapter presents four themes generated from the data. These are illustrated in Figure 8.1:

1. First impressions of 'Robots in Nursing;
2. The essence of nursing;
3. 'We must do something'- the need for debate;
4. Reframing the future- robots can assist.

Figure 8.1. Mind map of Themes and Subthemes from Nurse Leaders data



Each theme and subtheme is also presented in Table 8.1. and will now be considered in turn.

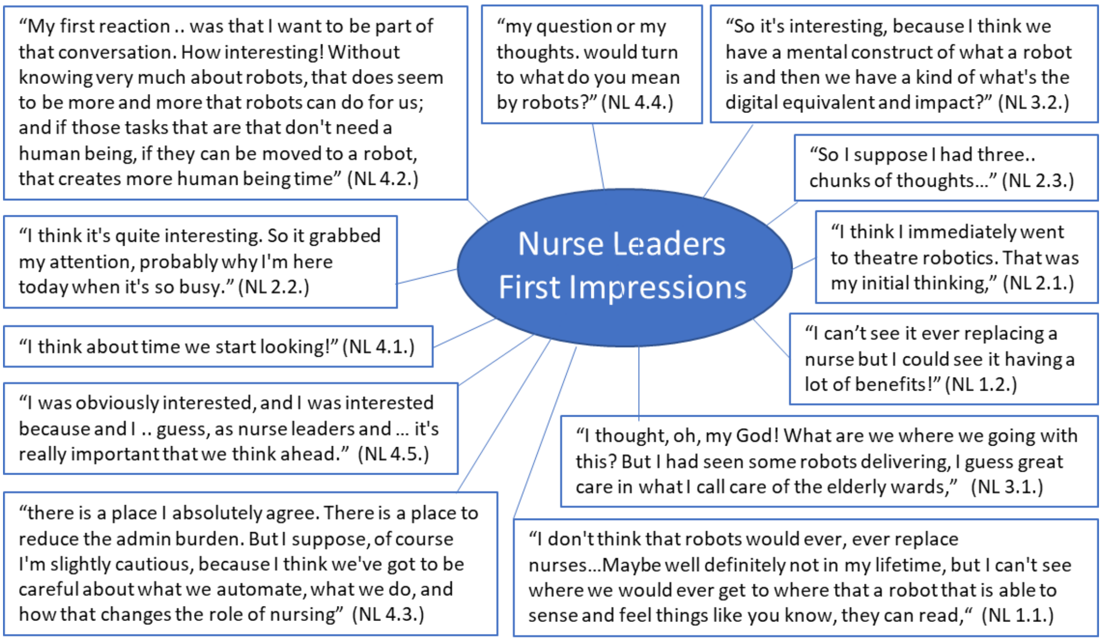
Table 8.1. Summary of Themes and Subthemes from Nurse Leaders

Table: Summary of themes and subthemes from Nurse Leaders Focus Groups		
Theme	Sub theme	Short description
1. First impressions of the topic	1.1. Current exposure to robots	Presents a graphic of the first impressions of the nurse leaders when asked to join the study and the participants comments on their current exposure to robots
2. The essence of nursing	2.1. What is nursing	Considers the contributions that identify the need to articulate what nursing is in order to consider the role of robots in nursing
	2.2. The unique contribution of nursing	Draws together comments about the need to articulate the unique contribution of nursing and the contributions that suggest what this unique contribution is
3. We have to do something: the appetite for debate and direction	3.1. Appetite to lead the debate	Presents the nurse leaders active voice, indicating an appetite to lead the debate and provide direction on the topic
	3.2. The need to address the workforce issues	Presents comment from nurse leaders that the future workforce shortages (including retention) present the rationale for a needed debate about robots in nursing
	3.3. We have to lead this before someone else does	The urgency of the need for debate is presented through expressed concerns of nurse leaders that others may decide before us and may make inferior decisions
	3.4. The need to redress the substitution/ reductionism commentary	Includes the comments that robots cannot substitute for nurses and notes that the debate had parallels in previous workforce discussions.
4. Reframing the future: 'Robots can assist!'	4.1. What robots can do for us	Includes nurse leaders' comments on the roles and graphic of six robotic roles
	4.2. Reframing the narrative as 'releasing time to care'	Presents a number of nurse leaders' comments that robots could release time to care by taking the burden of admin and other tasks
	4.3. Reframing the narrative as 'robots can enhance care'	Includes comments about how robots could make nursing safer or more consistent.
	4.4. The engagement journey	Includes incremental introduction, need to have nurse leadership and description of benefits

8.2. Theme One: First Impressions of Robots in Nursing

The first question in each focus group asked "what were your first impressions when invited to this focus group on the role of robots in nursing?" Whilst this was a helpful ice breaker, the data yielded important information about how the topic was first perceived. The initial response of each participant ranged from curious to cautious (Figure 8.2). It was notable that even the most cautious or reticent responses had an element of positivity and willingness to explore the topic.

Figure 8.2. First impressions of Nurse Leaders to 'robots in nursing'



8.2.1. Current Exposure to robots.

After citing their first impressions, a number of participants went on to refer to their previous exposure. For instance, one participant talked about phlebotomy and ophthalmic endoscopy, another talked about a cleaning robot and a delivery robot in hospitals and three others in the same focus group referred to surgical robots in theatres (NL 2.2., NL 2.3. and NL 2.1.) as follows:

"For example, we've already got the technology to have phlebotomy taken by robots. We don't use it… We can do these things…Endoscopy by AI, it's fantastic. We did it over 5 years ago, we published it." (NL 4.4.);

"But I'd also seen cleaning robots in my previous organisation, so I was curious about where this might go?" (NL 3.1.);

"we've got a robot … It's a penguin thing that goes around and delivers different things. Pharmacy, I think". (NL 1.2.).

Reference was also made to robots outside the health setting such as a hotel robot in America:

"I stayed in this hotel in New York. and they had so you know, for room service and things like that. If anything you asked for it was all done by robots, they would give it to the robot. The robot will come and deliver it, and you could give the robot something. They send a robot up when you finished with your dishes and things, and they'll take it away." (NL 2.1.).

Nurse leaders were therefore generally positive and cited the importance of the research, often relating this to wider experience of robotics.

8.3. Theme Two: The essence of nursing.

This theme encompassed the multiple references made, and the parallels drawn around, the essence of nursing as encapsulated by the nurse leader who exhorted the focus group to articulate..

"the essence of nursing that people value, that you wouldn't want to give up" (NL 4.1.).

The two subthemes of 'What is nursing?' and 'The unique contribution of nursing' overlapped but there was specific reference to each across the focus groups and therefore each was considered separately.

8.3.1. Subtheme: What is nursing?

Nurse leaders argued that in order to properly consider the role of robots, there needed to be clarity about 'what is nursing?' This point was argued in relation to one person's recent review of a robotic nursing study in theatre:

> "*But I wondered why you needed to be a nurse to do what they were talking about, so I guess my thing is what do we mean by nursing?*" (NL 2.3.).

Within the data, assertions of nursing being complex and involving judgement and assessment were mentioned multiple times and were presented as core to nursing.

Complexity in the practicalities of clinical care was commented on in relation to patient need and in the nursing response, as this example shows:

> "*I don't think people don't realise how complex it is: people and nursing…. You know, because there's so much variation in there and complexity"* (NL 1.2.).

It is interesting that this was framed as other 'people', implying that the complexities might be well understood within the nursing profession. However, nurse leaders described this complexity differently, e.g. one leader described complexity in terms of the number of people involved in an activity:

> *"Personal care is quite complex, you've got a whole lot of dynamics to it. Yeah, why is it high risk? why is personal care high risk in the context of health and safety is because you've got 2, 3, 4 bodies. They're all moving independently of each other to move or do something to achieve something. So .. then put a*

> *robot in, it can interpret and deal with that. That's hugely complex compared to where we are now."* (NL 3.2.).

Another nurse leader drew out the difference between complicated and complex, which she referred to as the level of judgement and uniqueness of solutions:

> "*the difference between complicated judgments and complex judgements. You can probably learn complicated but complex, where there might need to be a completely unique solution because of whatever requires, I think, requires a different level of thinking…. Well, it's that tacit knowledge again isn't it again? It is ..complex, it is not just complicated…Can you get me an extra bed sheets, or .. I need another yoghurt or bring me the commode are straightforward, uncomplicated tasks. It's not the same as using judgement, and certainly not the same as using judgment in complex situations*" (NL 2.3).

Others attempted to articulate the skill of nursing, referring to the 'linking' aspects of judgement, and in the second quote below describing the integrated nature of both physical assessment and clinical judgement:

> "*Because that's the skill of a nurse, isn't it? is to be able to elicit and then link things together*." (NL 1.2.);

> "*You know where you're turning a patient, you know you are looking at more than just repositioning the patient. You're looking at their pressure areas, and you, you know you're assessing the patient, you're talking to the patient.*" *(*NL 2.2.).

These contributions attempted to describe what nursing is and alluded to skills which are complex and included cognitive processes of linking information rather than the delivery of a set of tasks.

8.3.2. Subtheme: The unique contribution of nursing

A number of participants referred to the unique contribution of nursing but did not define further. Instead, the contributions suggested an implicit understanding within nursing leaders:

> "*…we need to be going back to the question of …what it is to be a nurse, and what's different and what's our unique contribution, and how do we articulate that?*" (NL 2.1.).

One participant suggested that the unique contribution of nursing was connected to the extent of the relationship, not just its compassion, but its extended time period:

> "*If you were to take it down to the unique contribution, I think nurses have that desire to have a compassionate relationship that goes beyond 5 minutes, and I'm picking that timeline, because, you know, medics will come in and come out,… Paramedics…. these longer term relationships, …if they wanted to do that, they'd have become a nurse. And maybe this is the area where you really drill into the unique. It isn't about the scale, this isn't about the technical knowledge, it's not about the ability to draw something up and calculate a drug, because there are any number of people that can do that in all the different disciplines but it probably comes… it's possible that it actually just comes down to that genuine desire and worth that comes from having a human relationship over a period of time*." (NL 3.2.).

Others also picked out the relational aspects of care as the unique contribution and linked the importance of relational and interactive aspects of care with the prospect of loosing this aspect with the digital agenda. One referred to this as the 'nurses' lament' that nurses felt they were missing out on aspects of holistic care:

"Nearly all 'care' was not delivered by registered nurses and the few registered nurses I spoke to, were lamenting the tension that they couldn't care…The average registered nurse on a ward is not fulfilling the full holistic function and role that they would want to be fulfilling. They don't have the time, they don't have the space, they don't have the resources," (NL 3.3.);

"There is something in that isn't it, because you know the reason I've enjoyed my ..career as much as I have is that interaction with patients, and that's where you get your job satisfaction, don't you? You know those relationships and those connections. But equally there's a lot of frustration because you just haven't got enough time to spend with ...patients, so I don't think it has to be all or nothing, but it would be a huge, huge change?" (NL 2.2.);

"*I think nursing and when you think about nursing and how it is defined, the most important aspect of nursing is it is relational. So what we do is relational and what we do uniquely in terms of our unique contribution is relational with patients, and to loose, I guess, there is a risk of loosing that, but more and more that we digitise in terms of what we do*" (NL 3.2.).

This data suggested that nurse leaders regarded relational aspects of nursing as part of the unique contribution of nursing together with the ability to assess and use professional judgement in complex situations.

8.4. Theme Three: 'We must do something'-the need for debate and direction.

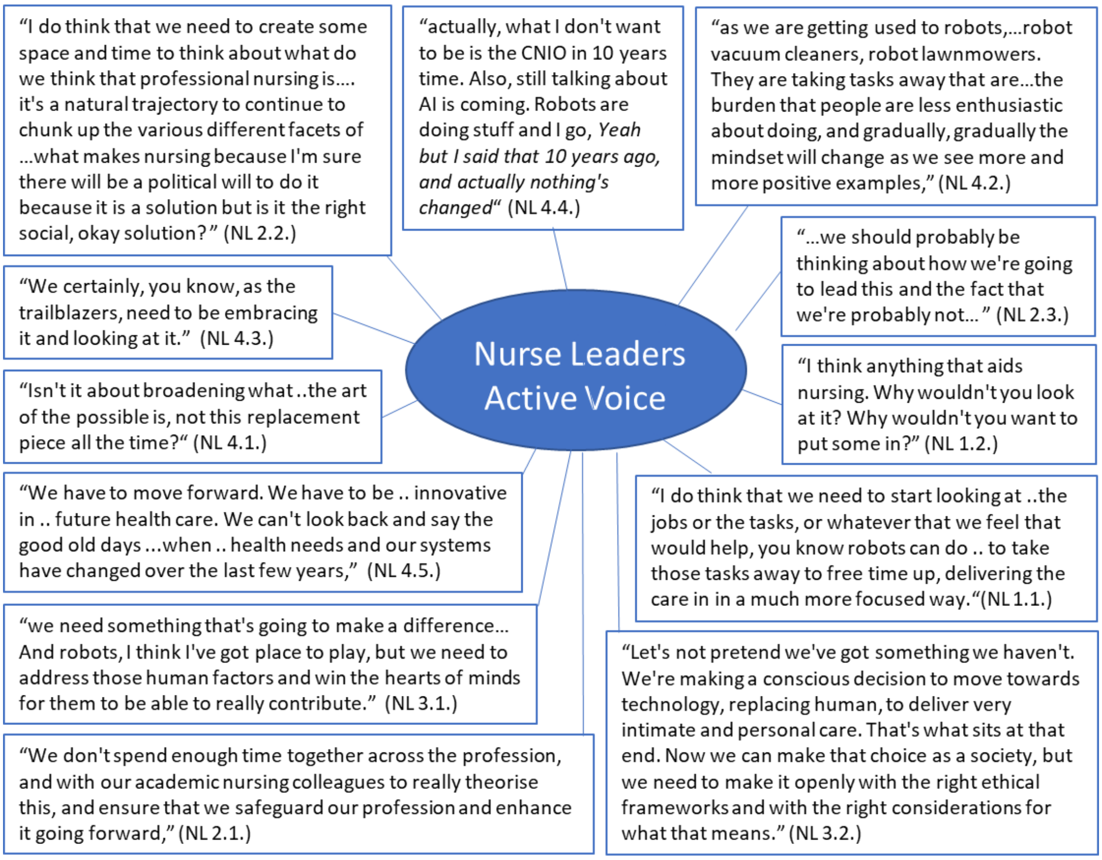
Many of the nurse leaders emphasised the importance of considering robots in nursing and their appetite to explore further with urgency. This was best encapsulated in the declaration of a national nurse leader..

"we have to do something!" (NL 4.5.).

Whilst the unifying theme was the need to do something, the reasons for doing so coalesced around four separate justifications which have been treated as subthemes. A significant number of the nurse leaders explicitly expressed their appetite to lead the debate which constituted the first subtheme. The need to address this urgently due to the workforce challenges has been presented as subtheme two, and the opportunity to do this pre-emptively has been presented as subtheme three. Subtheme four considered the need to redress the substitution commentary and avoid reductionism.

8.4.1. Subtheme: The appetite to lead the debate

Figure 8.3. Active voice of Nurse Leaders to lead the debate



During the nurse leader focus groups, there was a strong interest in leading discussions about the role of robots. This was unsurprising given that the focus groups included nurse leaders with specific digital responsibilities. Some emphasised the need to be "*trailblazers*" and expressed frustration with the possibility of no progress in the next 10 years. This desire for an active involvement in theorising and shaping the future of nursing was consistent throughout the data set (Figure 8.3). Two participants also voiced the urgency as well as the appetite:

> "*actually quite might sound really futuristic but actually the future is already here isn't it?* " (NL. 2.3.), and

> "*I think we do need to create more space for these conversations. I agree with urgency*" (NL 2.1.).

8.4.2. Subtheme: The need to address the workforce challenge

Workforce challenges were cited as a major driver to considering robots across the nurse leader focus groups. One nurse leader referred to the current crisis, quickly qualifying her opinion to assert that robots could not replace much of what nurses do:

> "*And obviously timely because of our workforce crisis, and not suggesting that robots can replace a lot of what we do. But I would be really interested in.. that debate around what can they do that that would release more time to care?*" (NL 4.5.).

In suggesting that robots might release nursing time, this nurse leader implicitly laid down a boundary around robotic substitution which has been further explored in theme four. Others implied the need to address shortages by referring to overseas recruitment as not the answer or the current unsustainable position:

> "*We cannot sustain who we are as a profession currently in this current NHS, so we've got to be proactively looking at innovation, and how we utilise nursing in the best way possible*" (NL 4.3.);

> "*But unless we try these things, we won't advance, so it's like I guess, an analogy of sort of horse and carts and cars. We moved from horse and carts to cars, but it took a while to get there…So …we're on a trajectory to get to that point but it's ..obviously taking us many years to get there, but we have to start…*" (NL 4.5.).

Workforce challenges were clearly seen by nurse leaders as creating the necessity to consider robots however, it was also recognised that this exploration may not be limited to nurse leaders and that there was a risk of others taking decisions on behalf of nursing.

8.4.3. Subtheme: The need to lead before others do so on our behalf.

In three of the four focus group discussions, participants mentioned others who might get involved in the decision-making process regarding nursing robots, such as other executive colleagues, politicians, and policy-makers. This created a sense of urgency to pre-emptively lead the debate and plan the future "*before they do*" (NL1.2.). One participant questioned whether non-nursing professionals, such as ministers, would view the use of robots as an opportunity to increase productivity and avoid issues such as nursing strikes.

> "*If we weren't nurses, and we were looking at it as like ministers, would we think the jobs could be chopped up and the continuation of a sort of Taylorist approach to productivity be enhanced so they didn't have to deal with what they've had to deal with?, […] about strikes? […] because robots don't need any rest?*" (NL 2.3.).

The reference to a 'Taylorist approach' implied a concern that nursing tasks might be divided into small, manageable chunks and delegated to robots. However, this suggestion was made sardonically, with the participant acknowledging that robots did not require rest. There was also a concern that decisions regarding robot use would be driven by cost rather than the needs of nursing and that the voices of nurses could be silenced or overridden. Nurse leaders discussed the potential for wrong decisions to be made or for negative impacts on the nursing profession if others were to lead the agenda:

> "*I'm an exec director, so I could see some of my colleagues going 'Oh, well, that's great. It's cheaper to have the robots than the nurses. you know we don't have any HR issues and all this kind of things'. I could just see that, […] I think we should explore it before someone comes up with it, and then says, 'oh, you know, we've made Freda and she's now the nurse of the future, and we haven't had any..*" (NL 1.2). "*input and you're gonna just have to work with these Freda's*" (NL1.1).

The mention of "Freda's" implies that decision-making would have been subpar if left to others. Additionally, the phrase "*we should explore it before..*" indicated a sense of urgency to take charge of the decision-making process and implied that others may consider replacing nurses.

8.4.4. Subtheme: The need to redress the substitution commentary and avoid reductionism

Discussion around substitution of nurses by robots occurred in each nurse leader focus group as the results of Phase Two (the RN results) were shared. Several suggested such substitution was not a possibility, e.g.

> "*I would never be scared that the nurses would be out of a job,*" (NL 4.5.).

Others commented on the fear of substitution:

> *"the first thing that jumped out to me when I just reading some of those, is fear and fear, from our professional perspective of what this might do."* (NL 3.1.)

and

> *"It's fear… you know, whether they think ..they won't be needed any more."* (NL 4.3.)

Whilst this 'fear' or reticence was implied to belong to others i.e. not nurse leaders, there was some suggestion of implicit resistance such as the

> *"I don't whether it's poking me as a nurse thinking, it's saying that if I could do what you've done all that training for, and all that expertise."* (NL 1.2.).

This insightful response indicated that some resistance may be more implicit even when explicit reservations are voiced.

A number of participants commented on how the RN perspectives seemed to have been influenced by the values of the RNs themselves particularly if RNs favoured a more reductionist (breaking down into smaller parts), approach, e.g. one nurse leader expressed surprise (and implied criticism) at what nurses wanted to delegate to a robot:

> "*I was surprised on the last one, the psychosocial, how much that nurses were willing to give up to a robot, I think I found that interesting, and concerning…It's starting to reflect kind of how people's, their own values about nursing. It feels a little bit like that. Do I value nutrition, and the management of nutrition as part of my role as a registered nurse and what that means and looks like?*" (NL 2.1.).

Another participant commented similarly on what this might mean for nursing:

"*I think it's interesting that what they think what they would like to opt out of, that's an interesting one about nursing*". (NL 1.2.).

Nurse leaders in each focus group also identified parallels with previous workforce redesign debates, and specifically to nursing discussions about what could be delegated to volunteers, healthcare assistants or the new nursing associate role:

"I'm thinking about the cultural piece, and you know whether it's at the almost volunteer end of the scale or the advanced end of the scale in workforce. It's the same kind of narrative isn't it, … you could take out the word robot and put volunteer in there because it's the same worries that people have …it's just workforce transformation isn't it? It's the same worries and risks and cultural worries that people have" (NL 4.1.).

"I noticed when we were introducing the nursing associate role. We did these tabletop exercises with ward teams to look at introducing the role into teams, and they completely took a real reductionist role focus… They took it into tasks, and I was really gutted and disappointed around that" (NL 2.1.).

This later comment about nurses taking a reductionist approach, appeared to galvanise a need to strongly reframe the future narrative, as the same nurse leader continued:

"*So when I then think about ...'take a nurse out put a robot in, what's different?' then yes, then we need to be going back to the question of what is what it is to be a nurse, and what's different and what's our unique contribution? and how do we articulate that?*" (NL 2.1.)

This subtheme captured nurse leader perspectives on the RN data. They recognised parallels with previous workforce transformation discussions and suggested the need for a strong narrative on the way forward.

8.5. Theme Four: Reframing the future – Robots can assist

This fourth theme built on the ambitions to do something and to redress substitution fears by reframing the narrative to one of robotic assistance to nursing. This theme firstly considers the sub-theme of nurse leaders' perspectives on what activities and roles robots could undertake, then three future narrative sub-themes of releasing time to care, robots can enhance care and the engagement journey are presented.

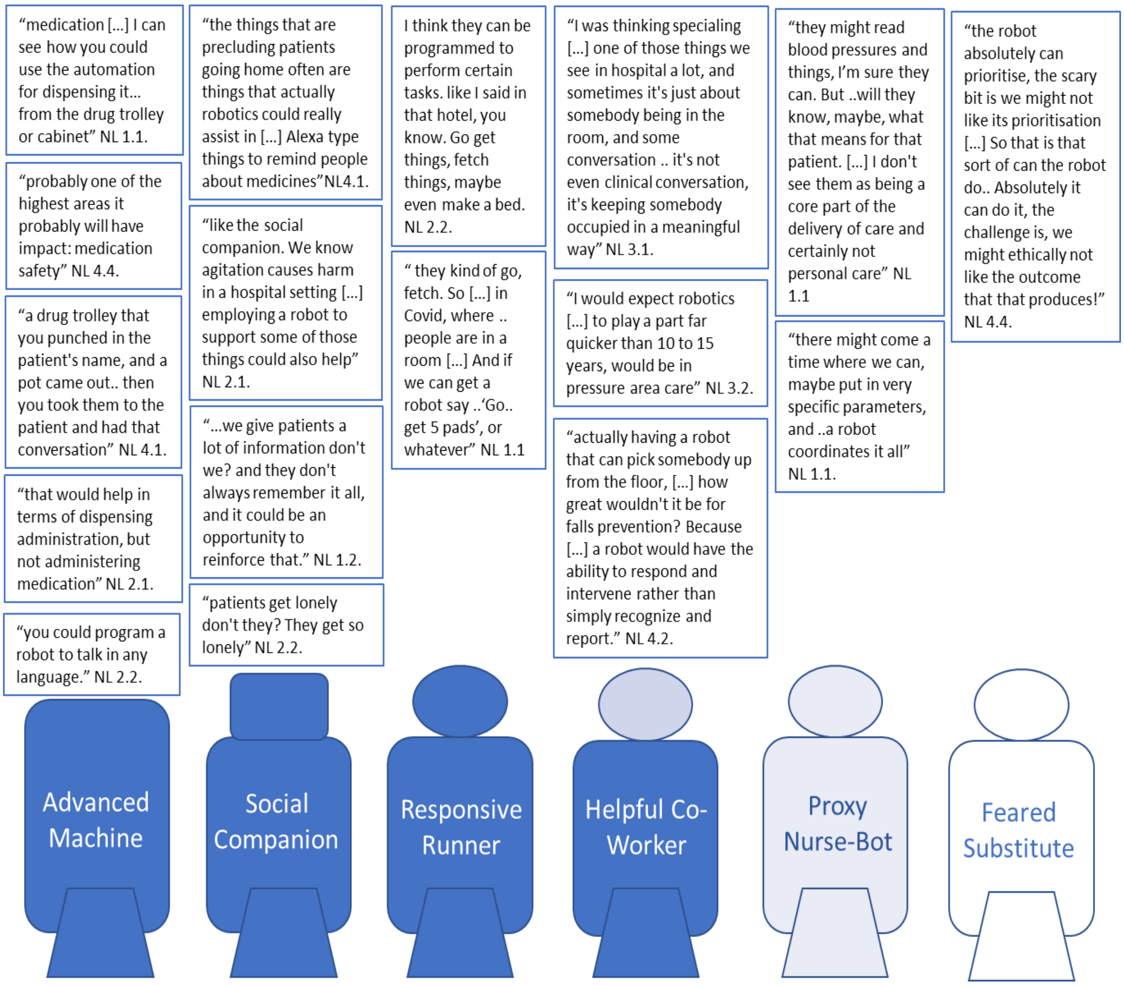
8.5.1. Subtheme: What robots can do for us

In considering what roles robots may undertake in the future, nurse leaders commented on the RN responses. Representative comments are presented in Figure 8.4. below, in which the contribution has been categorised according to the robot roles identified in Phase 2.

There was a focus on assistive roles while the time-saving opportunity was explicitly mentioned in focus group 4 (and then by several participants) and alluded to in other contributions such as dispensing medication and 'fetch and carry' tasks.

Overall Figure 8.4 illustrates that there were more comments (and more support) for activities that fell into robotic roles with lower autonomy, than those roles with more autonomy. The control of the nurse was similarly implied in contributions such as the two '*go and fetch'* comments which emphasised explicit nurse direction and the iteration of '*reinforcing information'* (which the nurse has given, rather than giving new information). The contribution about 'specialing' patients (terminology for close observation usually on a one-to-one basis), follows a similar pattern with the nurse leader emphasising that the conversation doesn't need to be clinical.

Figure 8.4. Nurse Leader comments on Robot roles in Nursing



Nurse leaders explicitly rejected the substitute role and robotic roles which provided hands-on nursing care, with little appetite for the 'proxy nurse-bot' role although there was discussion about what it should be called, with one leader expressing an aversion to including any form of nurse in its title. One nurse leader argued that robots could not replicate nursing skill:

> "*I think there's definitely roles that they could play in the delivery of to support the people that deliver care. I think I can see them a bit more in the peripheral. I think, when it's I think anything that standardised, routine, that doesn't have much variation I can see. I can see them playing a role, but not doing, not*

delivering the care, though I don't see that at all, because I think that is a very skilled undertaking." (NL 1.2.).

Other reasons for rejection included questioning the physical capability of robots exemplified by comments about their manual dexterity (NL 1.1.and NL 2.1) and the intelligence capability of the robot to apply reason and judgement (i.e. NL 2.3.). One nurse leader challenged the RN appraisal of robots being unable to co-ordinate care suggesting that robots could prioritise but nurses might reject robotic prioritisation, giving an example from the film 'iRobot' where a robot prioritises who to save from death (NL 4.4.). This illustrated that nursing decision-making may be fundamentally different from algorithmic robotic decision-making.

In terms of medication, one nurse leader delineated between what the robot might do, and the nurse must do by differentiating between dispensing and administering medication:

> "*So when I think about the safety element of how you could use robots as a tool towards safe administration or systemize robotic system to administer medication against a chart. I can see that there's elements in that that would work, but actually understanding the discussion around, you know 'why you're taking these medications, what this is for, how that's interacting with that one. How did that make what you feel?' You know how someone's reacting to it? Assessing all of that would be a nurse. So you can see the value, so I can see some safety elements that would help in terms of dispensing, but not administering medication.*" (NL 2.1.)

The description of the robot as a tool and as a system clearly allocated the robot role to one of machine rather than a 'being'. This was further reinforced by the assertion '*against a chart*' directing that the robot must follow a programmed approach. This was in contrast to '*understanding*' which was firmly seen as the nurse's prerogative. As the person with the patient contact, the nurse can ask open-ended questions, and take an overview particularly in evaluating of the effect of the medication. Similarly, the control of safety was delineated too with the robot contributing to safety through systematic procedures which '*help some safety elements*'. Whereas by contrast, the terms '*assessment*', '*interacting*' and '*reacting*', were used when describing the nurses' role in medication safety suggesting these aspects should remain under the control of the nurse.

8.5.2. Subtheme: Reframing the narrative as 'More time to care'

Another strong facet of reframing the narrative was the notion that robots could release nursing time. This was described as '*releasing time to care*' by some participants and as '*addressing the burden of administration*' by others as these contributions exemplify:

> "*Yes, there is a place I absolutely agree, there is a place to reduce the admin burden*". (NL 4.1.);
>
> "*and releases time to care for some of the other professionals that are around*" (NL 3.1.);
>
> "*so if that* [nurse alerted to patient fall] *can be automated so that there is more time to release, more time to care.*" (NL 4.5.).

Whilst the phrase 'releasing time to care' had its origins in the productive ward initiative, the emphasis here was that robotic *automation* would free the nurse to do something that would not otherwise be done. '*More time to care*' was suggested as an alternative. This impliedthat nurses (and others) would be able to do something *more* valuable. A similar point was made about robots relieving the burden as this nurse leader described:

> *"I suspect that over time, as we are getting used to robots, you know, robot vacuum cleaners, robot lawnmowers. They are taking tasks away that are the tasks that are the burden that people are less enthusiastic about doing, and gradually, gradually the mindset will change as we see more and more positive examples, and…the interesting point to me is just you having these conversations, it sounds as though you're just that of itself has made people think a bit differently about what the possibilities are"* (NL 4.2).

It is notable that these examples were explicitly framed as ways of presenting the narrative, including the observation that this research itself may be future forming by reframing the narrative in order to help nurses to consider using robots.

8.5.3. Subtheme: Reframing the narrative as 'Robots can enhance care'

Nurse leaders commented about the benefits and positive advantages of robots and with the suggestion that robots may be able to add something to nursing or perform some delegated tasks better, e.g.

> *"they [nurses] need to switch their mindset to is you'll have more time to do that, because the tasks are done for you actually, and they're done safer".* (NL 4.3..)

A clear desire to reframe the substitution narrative was apparent, as these participants describe:

> *"Everybody thinks of robot, you know some kind of replacement human being, and there isn't that thought around if a robot was taking a burden away from me. I could provide better, respectful, dignified care*" (NL 4.1.);
>
> "*..a lot of robotics on nursing is in the replacement space as opposed to how does it complement? How does it empower? How does it ensure that we can use our registered nursing workforce?*" (NL 3.2.).

Several nurse leaders mentioned the importance of safety and shared their experiences of up to 50% reduced medication errors rates following implementation of electronic prescribing / medication administration support. Citing these examples of how technology enhanced the safety of clinical care, highlighted the usefulness of inbuilt safety mechanisms that staff relied on, which are missed during technical downtimes. In this sense, particularly when considering routine repetitive activity such as medication dispensing, robots were characterised as making processes safer, although some questioned whether robots themselves could present a safety risk to patients.

Consistency of process was one area where robotic processes were seen as superior to human process. One participant argued that robots could consistently share information and empower patients to access it in an accessible form and means. This emphasised the importance of consistent information and suggested a wider need for nursing consistency.

> *"there's a lot in their* [intelligence] *that robots could do, and they might be able to do it more consistently than we do. […] I think the robots have got the potential to be consistent".* (NL 3.1.).

8.5.4. Subtheme: The Engagement Journey

Whilst there was a strong desire amongst nurse leaders to reframe any debate about robotics in nursing to one of assistance, it was acknowledged that other stakeholders needed to be considered: in addition to nurses both patient and other disciplines were mentioned as in this contribution:

> "*this isn't just about nursing, adoption and nursing engagement. The context in which we work, our patients need to be comfortable with it. Our doctors, the whole multidisciplinary team really, have got to go on a bit of an engagement journey here together*" (NL 4.2.).

The description of an engagement journey suggested a process of acceptance which was also alluded by others with the incremental nature of introduction explained by a nurse leader with a background in technology introduction:

> "*So I think the narrative around it is really important, and I think quick wins, I think. But you know anything that realises benefits, I think you know tiny steps. So removing 'robots', putting 'support in and helping you', and then realising the benefit. That's how you get them on board, because then, for all their fears, they go. [...]. So I think the minute that you give them tangible benefits that improves their working day, you get them on board then, and then you can push them a bit harder then, and go 'actually, this next one is a little bit more tricky, but we'd like you to try it'. Just remember how good the last one was*". (NL 4.3.).

This advocation of a step-by-step process to get nurses on board with reference to needing to 'push' adoption, suggested that resistance or reticence was to be expected and could be overcome by describing benefits, changing language (from robots to support) and incremental and closely supported introduction.

8.6. Chapter Summary

This chapter presented the results from the four nurse leader focus groups and presented the first reactions of the participants, which were positive about the opportunity to explore the topic of robots in nursing, considering it timely and important. The first theme articulated the need for nurse leaders to be able to clearly define what is nursing and its unique contribution in order to then consider what role robots might play in the future.

There was a clear appetite to lead the debate and future direction on this topic, firstly to consider the contribution to the workforce challenges, secondly to do this ahead of any political or local decision-making, and thirdly in order to redress any notions of robots replacing nursing or a reductionist approach to sharing out tasks. The chapter then considered the key messages in reframing the narrative of how robots might assist care, firstly in terms of the roles robots might undertake, and secondly as robots can release time to care and may enhance care. The chapter concluded with the recommendation of a step-by-step engagement process to introduce robots.

These findings, and those of chapters 6 and 7 will now be discussed in the following chapter.

Chapter 9: Discussion

9.1. Introduction to the Chapter

At the beginning of this thesis, the salutation referred to “Here be Dragons”, a term used on ancient maps to describe an unknown and unexplained area (Waters, 2013). This study has explored and illuminated a largely unknown yet inevitable area of the future: the role of robots in hospital nursing. This chapter summarises the three results chapters against the study objectives before considering the results in the context of the literature. This chapter then discusses the nursing response to a future reality by exploring four facets of the next steps; policy development; robot development; the preparation of nurses and the impact on the profession of nursing. Throughout this chapter, the focus is on how nursing might navigate a future involving robots using a set of ‘navigational aids’ (Figures 9.1., 9.3., 9.4. and 9.5.).

In this discussion, the terms registered nurses (or RN) and nurse leaders will be used to distinguish the perspective of the two categories of nurses studied in this thesis, with the generic term ‘nurses’ used when the results refer to both groups.

9.2. Summary of thesis findings

The first objective of this study was to explore the perspectives of roboticists about the future capability of robots in the next 10-15 years. During the study, a taxonomy describing the level of automation and autonomy was developed. This enabled the roboticists to confirm their current level of robots and estimate robotic capability in the next 10-15 years. According to roboticists, robots will not replace nurses but will be able to assist nurses in providing care in the next 10-15 years. Robots are likely to be operating at the level of conditional automation, where they perform some tasks independently and notify nurses when their intervention is required. Despite the rapid advancements in robotics and AI, the use of robots in healthcare will still be limited due to the challenges posed by unpredictable environments and the complexity of nursing. For those who are wary of the potential for robot autonomy or who fear substitution, there can be reassurance that this is unlikely to happen in the short term. Nevertheless, this study finds that robots **are** likely to become a reality in nursing in the next 10-15 years.

The second objective was to explore nurses' perspectives of what might be acceptable roles and activities that robots could undertake in the future. Nurses were supportive of robots undertaking discrete activities that did not require complex judgement such as vital signs recording or repeating information. Nurses were also supportive of robots directly assisting nurses by supporting a patient body weight in mobility and moving and handling procedures.

Nurses confirmed acceptance of an increasing robotic role as an extension of the use of machines in health care. However, they were hesitant about more autonomous roles emphasising the complex interpersonal nature of nursing and questioning whether robots could act with empathy or undertake comprehensive individual assessments, such as responding to subtle physiological changes in patients. This study coalesced patterns in the RN data around six roles that nurses envisioned robots undertaking, ranging from advanced machine and social companion through to advanced but less acceptable roles which mimic nurse capability and substitute for nurses.

The third objective for the study was to identify the barriers and enablers for robotic introduction and this study found that nurses expect robots to be a part of future nursing but held a range of perspectives which could act as either barriers or enablers to adoption. Some nurses saw it as an opportunity to focus on higher clinical skills, while others saw it as an inevitability that they must accept. There were those who were excited about the prospect of robotic support, envisioning the value of such technology if nurses could control and manage the robots. However, there were also concerns. Some nurses feared that patients may not accept robots, and many nurses were preoccupied with concerns about the future. One major worry is that the current shortage of healthcare workers, will worsen. Paradoxically some nurses were fearful of being replaced by robots, and consequent unemployment. Some participants also suggested that robots may increase nurses' workload, with additional responsibility to manage, direct, and fill in the gaps for tasks that robots cannot do. They were also fearful of using the technology and there was significant concern about the potential malfunction and subsequent non-availability of robots and the resultant impact on patients and nurses. There was also apprehension that robot use could diminish nursing skills in the long term.

The fourth objective for this study was to make recommendations for the future and this study identified a need for greater engagement, preparation and leadership from nurses. For robots to be useful, nurses must engage to influence future development and roboticists need to engage with nurses to ensure clear alignment and understanding about what is possible from a technical perspective. Currently, there is little evidence of this working relationship between nurses and roboticists.

Nurse leaders emphasised the importance of leading the debate on the role of robots in healthcare. While they were supportive of robots' assistance, they were resolute that robots should not replace nurses. For example, in medication management, the risks of administration to patients who have difficulty swallowing medication were cited. Additionally, some nurses argued that medication administration goes beyond simply dispensing tablets and provides an opportunity for patient education requiring a nuanced approach tailored to the patient's understanding. One nurse leader asserted that robots should only assist with dispensing, and not administering medication thus differentiating between substitution and assistance. Nurse leaders therefore pointed to the need to articulate the assistive role of robots and reframe the discussions.

9.3. Situating the findings in the context of the Literature: What *should* Robots do?

Table 9.1. provides a summary of what this study adds to what was already known from the literature and summarises the new knowledge that this study has created.

Table 9.1. Summary of what this study adds and new knowledge

Table: Summary of what this study adds and new knowledge			
Research Aim	**What was already known**	**What this study adds**	**New knowledge**
To propose likely scenarios of robotic capability, identifying likely technological constraints	Multiple Predictions of robotic capability and AI development Various taxonomies of robots Taxonomy of automation for medicine Predictive Taxonomy of nursing robots	Roboticists' perspectives of the future identified: robots will not replace nurses in the next 10-15 years but could assist The usefulness of a taxonomy for discussing robot capability confirmed Critique of predictive approach. Rejection of autonomous levels.	Development of a taxonomy of automation and autonomy specifically related to nursing Importance of Human warmth/ Empathy and Compassion
To explore and analyse nurses' perspectives on what might be acceptable and appropriate roles for robots in nursing.	Nurses' acceptance of Robots in healthcare What robots are already being used for: telemonitoring, telemedicine, rehabilitation (exoskeletons), patient moving and handling, fetching and carrying, some vital signs recording, medication dispensing and social support Technological Nursing Theories to guide nursing use of robots	Acceptance of use in hospitals for adult patients, patient moving and handling, fetching and carrying, vital signs recording, medication dispensing and social support including patient education, and translation. Plus administrative support/record keeping/information sharing. Support for tele-surveillance. Validation of the importance of human warmth, empathy and compassion for human nursing and robotic assistance	Overview of activities contributing to each element of including psychosocial support Fundamentals of Care Current nursing theory insufficient Six defined roles for robots aligned with acceptability for next 10-15 years identified Nurse Leader Perspectives on robots identified
To identify the factors that might help or hinder robotic use in the delivery of nursing care	Technology acceptance theory Appearance, education, gender and age impact on robot acceptance. Positive and negative viewpoints may co-exist	Elucidates range of viewpoints on robot acceptability. Confirmation that appearance, ease of use and perceived usefulness are relevant to intention to adopt. Fear and autonomy need to be considered	Four pre-requisites for technology adoption were identified: Nurses in control Troubleshooting procedures Gradual introduction Comprehensive Training
To propose how robots might contribute to the delivery of hospital nursing and Make recommendations for the next steps	Managers' approach to robot introduction explored.. Consideration of impact of robots on the profession Patients may feel less valued if cared for by a robot	Perspectives of Strategic Nurse Leaders in UK identified. Concern re Mastery / Teaching / Long term Impact on Nursing Autonomy and control is key to acceptance	Nurse leaders are supportive of leading debate and policy development, reframing the discussion to address substitution fears by focusing on robots undertaking an assistive role.

9.3.1. What activities can robots assist with?

This study concurred with literature findings that robots could assist with administrative support (Lee *et al*., 2018; Chang *et al.*, 2021), medication dispensing (Liang *et al.* 2019), vital signs measurement (Fuji *et al*., 2011; Lee *et al.,*2018) and patient mobility, lifting and repositioning patients (Turja *et al*., 2017; Christoforou *et al*., 2020; Lee *et al.,* 2022). This study built on the current literature in which nurses indicated their agreement of robot involvement against a defined list of nursing activities. Although the study by Lee *et al.,* (2018) was the broadest, it was biased toward physical activities, with '*communication with patients'* being the only psychosocial component. In contrast, this study extended beyond previous hospital studies using the Fundamentals of Care Framework (Feo *et al.,* 2017), and included physical, psychosocial, and relational nursing activities.

This study's qualitative nature also captured additional commentary on the complexity of nursing and the need for careful risk management. This was evident in the example of medication management above which echoed the views of Karttunen *et al.,* (2019). In another example, nurses caveated their responses about nursing assessment, arguing that it was more complex than simply recording the vital signs and invariably includes an assessment of pain, changes in position, and skin integrity. Whilst Roboticists concluded that these complex assessment skills were beyond the current robot capability, nurse leaders identified the potential for robotic surveillance as an adjunct to enhanced supervision of patients at risk of falls, deterioration or absconding. This finding advanced the results of Logsdon *et al*., (2022) who evidenced student nurse acceptance of a teleoperated robot acting as a 'patient sitter'. This suggested an opportunity as enhanced supervision of patients poses a significant resource and cost issue to hospital nursing (Jones, Aylward and Jones, 2019).

In terms of psychosocial support, this study identified activities where social robots could contribute, such as providing information, engaging patients in diversionary activities to help patients manage their emotions, and being present and facilitating social interaction. This added to the positive findings of previous studies focused on children in hospitals (Liang *et al*., 2019; Jin and Kim, 2020) and on general user acceptance in community settings (Vandemeulebrooke, Dierchx de Casterle and Gastmans, 2018; Papadopoulos, Koulouglioti and Ali, 2018). Additionally, nurses suggested that robots could serve as translators, consistent with the findings of Turja *et al*., (2018). Again, nurses caveated their responses, expressing resistance to robotic involvement with more complex forms of communication, such as educating patients and providing emotional support, citing the need for human judgement and the complexity and variation of such interactions. Whilst this concurred with the findings of Elgin *et al*., (2022) that nurses were concerned about robots lacking human warmth and compassion, this study added to those findings. Concerns in this study were so significant that almost all nurses expressed explicit resistance to robots providing empathy and compassion. Whilst nurses used the terms "compassion" and "empathy" interchangeably, (a phenomenon also observed in other studies i.e., Ortega-Galen *et al*., 2021) they also rejected robotic assistance with maintaining privacy and dignity and respecting values and beliefs. Primarily this was linked to the belief that such qualities could not be embodied within a robot. This finding represents fresh insight into nurses' perspectives of the importance of empathy, sympathy and warmth which concurs with the conceptualisation of nursing as a 'relationship' and confirms work by Kitson, Muntlin-Athlin, and Conroy, (2014) and Horton (2016).

Some might question if robots need to ***feel*** emotion provided they ***act*** compassionately leading to the question 'Can robots be programmed to act empathetically?' Robots are not sentient, do not have feelings and therefore cannot have emotional empathy (Barnard, 2017). However, robots are being developed to recognise emotions and respond in an empathetic manner ***as if*** they 'understand' the perspectives of others (Libin and Libin, 2005; Park and Whang, 2022). Parallels exist in human nursing where a nurse might not feel an emotional connection but chooses to act kindly. This confirms the need for robot development to progress the capability of robots acting empathetically and sympathetically.

Therefore, in terms of activities, this study supports and adds insight to the literature that nurses were supportive of robots undertaking predictable and easily measurable activities where no interpretation or judgement is required- or which alert the nurse when this is needed. This largely reinforces the current areas of robot functionality and informs the areas of future robot development and starts to elucidate the level of robot autonomy that might be acceptable to nurses which is discussed next.

9.3.2. To what extent should robots contribute?

At the outset of this study, it was anticipated that robots would be equipped with some form of artificial intelligence within the next 10-15 years. However, as the study progressed, greater certainty has shifted the focus to the *type* of artificial intelligence that might be available, including discussions around the availability of artificial general intelligence (AGI) and artificial superintelligence (ASI). While neither of these is likely to be available within the next 15 years, they are important drivers of robot autonomy. The taxonomy developed for this study was described as helpful in enabling nurses to clarify the level of autonomy they considered appropriate and providing a clear spectrum of automation which appeared easily understood.

Only one other taxonomy related to robots in nursing has been published and that in written form only (Tanioka and Locsin, 2017) and this was not updated in their second edition (Tanioka *et al.,* 2023), but see Figure 5.2. for a figurative representation. Whilst Tanioka and Locsin's four-level predictive model might be helpful for future policy planning, the suggestion that robots will manage nurses by 2050 may be perceived as alarmist in the context of this study where fear of the future was a significant finding. Thus, a nursing robot taxonomy was developed for this study which has similarities to other taxonomies, which adds face validity (Bhandari, 2022).

Using this latter taxonomy in the focus groups elucidated the importance that nurses ascribed to the control of robots. Registered nurses and nurse leaders both argued that being able to control robots was essential to ensuring patient safety. For RNs control was seen as a prerequisite which extends literature findings that nurses least preferred robots with the ability to self-learn (Zrinyi *et al.,* 2023). This requirement for control could also explain the divergence in nursing acceptance of more autonomous roles. Zlotowski, Yogeeswaram, and Bartneck, (2017) found that more autonomous robots were perceived as a threat to job security, resources, and safety. However, autonomy, including the ability to self-learn and self-direct, *is* a fundamental aspect of robot development. This suggests that robot autonomy may be an important consideration for future adoption, but it is not yet well understood nor been included in established technology acceptance theories. This was further endorsed by Balfin, Grobbel and Fuller (2019) who argued that nurses must consider if robots can support nursing care, and if so, what effect they might have on the *'sacred nurse-patient relationship'* (p.335).

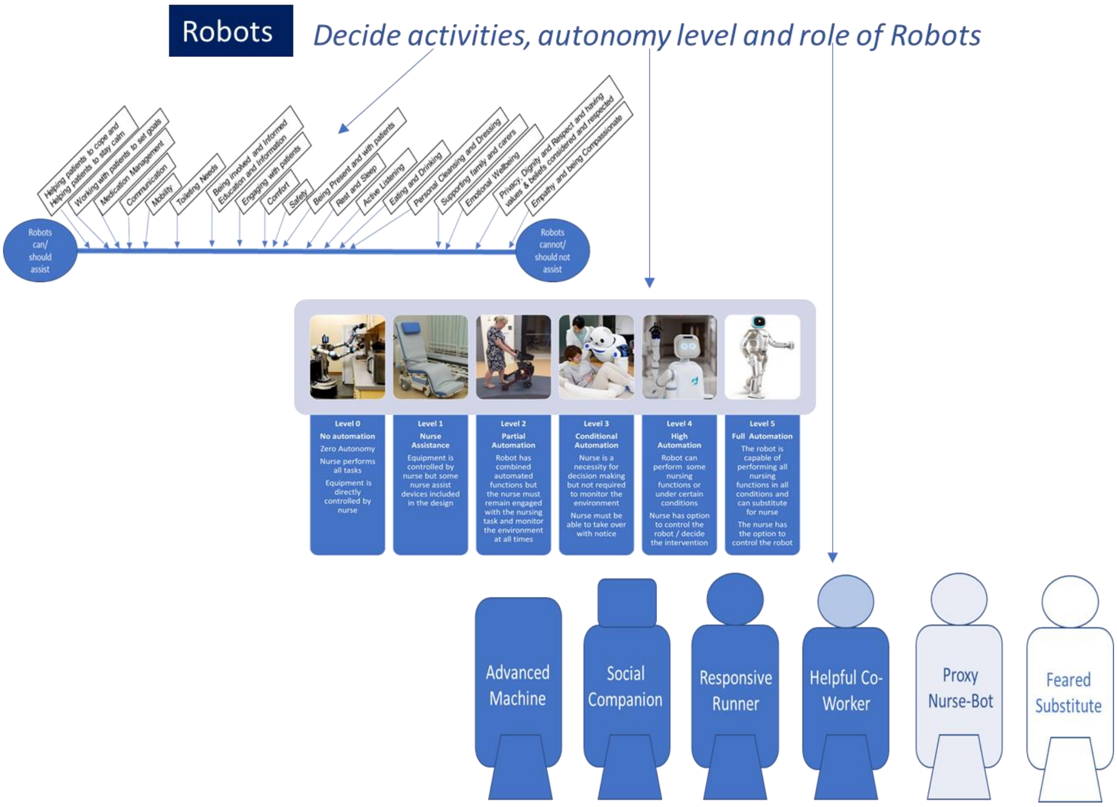
9.3.3. What robot roles are most acceptable to nurses?

In this study, nurses discussed the potential roles that robots could fulfil in the future and six roles were identified ranging from an advanced machine performing specific tasks under the direct supervision of nurses, to fully autonomous robots. Nurses generally welcomed robots in roles that would allow them to delegate tasks and focus on other important aspects of their work e.g. robots functioning as 'advanced machines' or 'reliable runners' enabled with tools like auto-transcription for clinical documentation. Additionally, robots serving as 'social companions' for patients was seen as helpful to both patients and nurses. However, the greater divergence on more autonomous robot roles with some nurses keen to delegate tasks and others keen to articulate the risks of unsupervised roles, illustrates the range of opinions. Opinions converged again on rejection of the role of 'proxy-nurse-bot' which brought together descriptions of a robot equipped to undertake most nursing activities but with some skills deficits such as clinical judgement and the ability to respond to unique situations. Similarly, the role of 'feared substitute' encapsulated a deeper level of discomfort with a more capable autonomous robot inciting fear and substitution concerns. Nurse leaders also rejected substitute roles.

The divergence in acceptance may, in part be due to perceptions of robot capability. There was a dichotomy as on one hand, nurses referenced the chronic shortage of nurses, and shared scepticism about whether robot capability would be sufficient for robots to be truly helpful. On the other hand, there was an expressed fear that robots would be ***more*** capable than nurses, placing nursing roles at risk. This explicit fear that robots might take their jobs, was perhaps fuelled by articles in the nursing press (Peck, 1992; Buchan, 2017), or in the wider press (Gayle, 2017).

Overall, the six conceptual roles provided helpful insight into how robots might function in nursing and suggest how new robot roles may be best positioned when introduced into nursing. These key components of appropriate activities, level of autonomy and robot roles will need to be considered and these frameworks may aid future discussions.

Figure 9.1. Activities, autonomy level and role of robots



Having confirmed that robots are likely to be a future reality, the activities robots might undertake, the extent of robot autonomy and explored the roles they might play in nursing, the next steps can be considered. Initially, it is worth considering how these findings relate to existing Technology Acceptance Theories discussed briefly in Chapter 2.

9.3.4. How well do Technology Acceptance Theories explain the findings?

Technology Acceptance Theories aimed to explain the factors that help the acceptance and adoption of technology. Even though the Technology Acceptance Model (TAM) concepts of perceived usefulness, perceived ease of use, and intention to use (Venkatesh and Davis 2000) were not explicitly measured in this study, numerous participants mentioned that robots must understand simple commands and be user-friendly, which emphasised the significance of "Perceived Ease of Use". Similarly, the robot's capabilities that are explored below could add to the "Perceived Usefulness". However, this study identified additional factors such as fear of substitution and fear of malfunction which do not fit within the TAM.

The UTAUT model (Chapter 2) included factors such as performance expectancy, effort, expectancy, social influence, and facilitating conditions (Venkatesh *et al.,* 2003). There is some correlation with results in this study as the four prerequisites could be categorised as facilitating conditions. The identified concerns about potential robot malfunction could be considered as performance expectancy, while concerns about robots increasing time might fall under effort expectancy and therefore be explained by the UTAUT. However, it is not an easy fit and the UTAUT model is not specific to robots or nursing and consequently underplays any consideration of the impact on the profession or job role which this study identified.

While the TAM and UTAUT models provided some insight into the adoption of technology in this study, they failed to account for negative factors that may affect the use of technology. Although scales such as the Negative Attitudes to Robots Scale (Nomura, Kanda and Suzuki 2006) captured negative attitudes towards robots, these scales were wide in their focus and not granular enough to consider the full range of nursing activities, e.g., a single rating for one question on ‘caring for the elderly’. Furthermore, the scales assumed that attitudes are either positive or negative whereas Koverola *et al*., (2022) demonstrated that positive and negative attitudes towards robots can coexist, which may explain why nurses may prefer an easy-to-use robot with some level of autonomy while rejecting autonomous robots that are not controlled by nurses.

In summary, the TAM and UTAUT models, and the Negative Attitude to Robots scales, do not fully explain the acceptance of robots in nursing, although the work of Koverola *et al*., (2022) showed more potential in this regard. Therefore, an alternative conceptual framework is required, perhaps not to predict nursing acceptance (as these acceptance models attempt), but rather to guide the discussions and decision-making about how to approach that acceptance. Given that robotic development is already in progress, the next steps cannot be linear or sequential and therefore four facets: development of policy; development of robots; development of nursing capability and impact on nursing, are proposed.

9.4. Policy Development

This study is the only one (no others have been found) whereby the views of strategic nurse leaders have been canvassed about the role of robots in the future. Ergin *et al*., (2022) examined the opinions of nurse *managers* who were mostly first-line managers rather than strategic executive leaders. Turja *et al*., (2018) included nurse managers among other managers but did not extract a strategic nursing view. The findings from this study are therefore significant in setting future priorities and conceptually fit within the outer ring of the Fundamentals of Care framework in Figure 2.1. (Feo *et al*., 2017) which refers to policy-level leadership.

This study found a need for a clear policy statement on how UK nursing should proceed in terms of technology development. The Topol review in 2019, made recommendations about increasing the digital skills of the healthcare workforce although did not identify smart buildings or robotics in nursing as one of the top ten technologies for implementation. Although there was some nursing involvement in the Topol review there has been a persistent gap in nursing leadership on the Board of NHS Digital, despite the appointment of a Chief Nursing Information Officer for England. Moreover, the focus of NHS Digital has been on the development of digital technologies and skilling of the workforce, with rather less progress on policy development.

Booth *et al*., (2021) recommended that nursing accelerate the transformation to a digitally enabled profession, upskill nurses, invest in and lead digital health developments and champion informatics across all areas of professional practice. However, a clear plan of delivery has yet to emerge and existing technology initiatives tend to focus on digital information technologies (such as decision-making tools) with no reference to robots. Some forward-thinking organisations such as the Florence Nightingale Foundation offer professional development to those interested in becoming digital champions. Whilst these initiatives will upskill interested nurses they fall short of the digital transformation recommended by Booth *et al.,* (2021) and omit to consider the impact on the future sustainability of the nursing profession. The obvious gap is the lack of direction on what technologies should be developed for nursing and the key underpinning principles. This study has crystallised the need for a policy direction that clearly articulates the role boundaries between human nursing and robotic assistance, identifies the unique contribution of nursing and reframes the introduction of robots as assistive technologies.

Previous workforce transformation initiatives may offer some transferable learning here. One of the chief nurses reminisced that the focus group discussion paralleled a previous survey of NHS staff about the role of volunteers in the NHS by The Kings Fund (Ross *et al*., 2018). Their report revealed that volunteers were performing diverse tasks such as wayfinding, delivering prescriptions, providing companionship, bringing therapy pets, playing music, and collecting patient feedback. Each of these activities mirrors those that nurses consider robots might undertake.

9.4.1. Policy imperatives

Some might criticise the introduction of robots in nursing as embarking on the 'slippery slope' toward robot substitution, with a corresponding disservice to patients. Others might regard this as a dissonance of naivete versus necessity, arguing that if nurses do not embrace technology (including robots) to mitigate the nursing shortage then they are already impacting those they serve through inevitable shortfalls in care. This in turn may accelerate the exit of human nurses from the profession with a consequent further loss of vital skills. The alternative however must be to harness the opportunity to integrate the developing technology into nursing in a way that values human skills supported by robotic capability where it is safe and profession-enhancing. National policy will need to set out guidance that builds the long-term sustainability of the nursing profession whilst also identifying the necessary steps in nursing preparation. The imminent publication of the Phillips Ives Review promises to inform strategy to ensure that nurses are given access to the education and skills required for safe, effective digitally enabled practice (Health Education England, 2023). However, it is not known if assistive robots will feature, if so the role of individual nurse leaders may be pivotal. Nurse leaders therefore need to engage and lead the debate and set the policy direction for the future.

Importantly the report by Ross *et al.,* (2018) has parallels here as they referenced a previous report indicating that high-quality services could not always be sustained without involving volunteers or other sources of informal care (Naylor *et al*., 2013) and broached the question of whether volunteers were substitutes or not (Ross et al., 2018). According to these studies, volunteer roles should complement staff and help free up time for clinical care by providing additional assistance i.e., extra eyes and ears (Galea *et al*., 2013). The same could be said of robot roles and indeed nurse leaders made similar recommendations in this study. Therefore, the first priority in setting the policy direction would be to confirm the purpose of robotic introduction and address substitution concerns. Nurse leaders articulated the principal purpose of robot introduction as enabling staff to release time to prioritise clinical care. However, a number of initiatives have promised this before such as the productive ward, (NHS Institute of Innovation and Improvement, 2011), and therefore careful consideration of the entirety of robotic operation will be needed so that the net impact can be clearly articulated in terms of time saved.

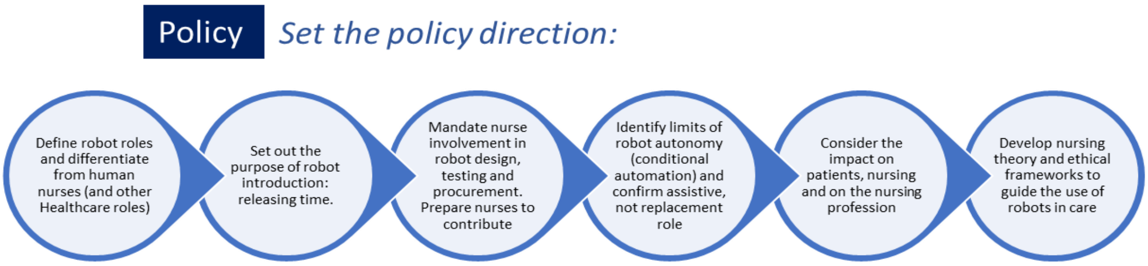
Articulating the purpose also provides the opportunity to directly address the substitution issue at policy level. The fear of substitution represents a clear barrier to adoption, so it will be important to confirm that substitution will not be considered for the foreseeable future. There are five reasons that substitution is not currently feasible or appropriate which should be communicated:

- patient opinion has yet to be explored and considered in the UK,
- robot capability is significantly below that of human general intelligence and as such unable to substitute for the range and complexity of human nurses,
- as yet robots have not been thoroughly tested and evaluated in the real-world nursing environment,
- nurses have a key role in safety vigilance which needs to be enhanced and not constrained by robotic usage and oversight,
- nurses have an important role in developing nurses of the future and must safeguard the ability of the profession to continue to provide a safe nursing resource for the future.

Similarly, the Kings Fund report (Ross *et al.*, 2018) additionally emphasised the need for clear role boundaries as did the workforce transformation report which reviewed the introduction of the associate nurse role in England (Lucas *et al.*, 2021). This evaluation report highlighted the importance of differentiating the associate nurse role from the registered nurse, addressing the costs and complexities, and ensuring the readiness of the organisation to include and support the associate role (Lucas *et al*., 2021). Similarly, policy direction on robot introduction must provide clarity regarding role boundaries and differentiation from human nursing roles plus address cost and organisational readiness. Results from this study suggest that whilst robots could collect physiological information (such as temperature, respiratory rate, heart rate, blood pressure) robots should not be permitted to complete patient assessment. In assessing a patient, nurses use critical thinking skills and collect data both subjectively and objectively regarding the patient's individual physiological, psychological, sociological, and spiritual needs and plan care or undertake tasks that rely on nursing judgement (Toney-Butler and Unison-Pace, 2022). Policy will need to make clear what human nurses must do (such as plan, evaluate and oversee the use of robots) and the extent to which robots may contribute. The taxonomy developed for this study may assist here: 'Conditional automation' (where the nurse is a necessity for decision-making and must take over with notice) could perhaps be cited as the current limit for robot automation. However, such role boundaries will need regular review as robot capability increases. Given that the Long-Term Workforce plan (2023) will be reviewed every two years, this may be an appropriate timeframe.

Effective leadership will be essential to expand the opportunities and realise the potential (Ross *et al.,* 2018; Topol *et al.*, 2019). According to Brown *et al*., (2020), nurse leaders and champions should be involved in the development and evaluation of digital technologies to ensure that their design addresses the problems nurses face and that they are accepted and implemented. The analogy between health care and the airline industry is often made in relation to patient safety and is relevant here. Nursing is considered a safety-critical profession (Leary, 2017) and therefore needs to assume the role of pilot in navigating the route and safety of nursing care delivery. Policy imperatives will need to underline the importance of clear, strong nursing leadership at every stage of robotic development and implementation, reinforcing the recommendations of Booth *et al.,* (2021). Additionally, policy development needs to clarify the priorities for robot development for nursing, and the necessity of engaging nurses in design, testing and procurement. Policy must also make clear the mechanisms for the preparation of nurses and the nursing profession including supporting theoretical frameworks which will be discussed below. These multiple considerations are illustrated graphically in Figure 9.2. below.

Figure 9.2. Policy components



9.5. Developing Robots

This study suggests a clear set of priorities for robotic development. This includes development of robots that can assist in record keeping /administration, tele-surveillance, medication dispensing, lifting and handing and courier activities. This study also supports the ongoing development of robots capable of communicating empathetically and compassionately as this was a barrier to acceptance. Many of the identified functionalities are already in existence in some form and in particular social robots are beginning to be tested in hospital environments (Hung *et al*., 2021) and could be accelerated with the addition of translation and information-giving functionality. As robot functionality develops these priorities will need to be revisited.

9.5.1. Addressing reliability

This study also identified concerns about the reliability of robots which need to be addressed before robots can be introduced. These concerns aligned with previous research (Maaloof *et al.,* 2016; Metzler, Lewis and Pope, 2016), and reinforced literature findings that this is a major obstacle to robot adoption (Servaty *et al*., 2020). Additionally, this study identified concerns about the reliability and trustworthiness of robots as data handlers, consistent with previous research (Peek *et al*., 2014; Wu *et al*., 2014; Glende *et al*., 2016). Robotic development therefore must also resolve these reliability issues which contribute to resilience.

9.5.2. Addressing nursing involvement

A more difficult issue to solve is the involvement of nursing expertise in the development of robotic solutions. Without this involvement three issues emerge:

- Costly solutions may be developed that might not be usable in clinical practice (e.g. the hair-washing and skin-washing robots cited in Chapter 1),
- Solutions may be overcomplex or problematic to use so that users cannot realise the full benefit or may need to adopt workarounds to find a usable solution. Koppel *et al*., (2008) and Brown *et al*., (2020) documented poor design leading to downstream effects, including significant interruptions in workflow and the subsequent necessity for workarounds.
- Robotic development that may be useful and save time may not be given sufficient priority.

Each of these issues can be addressed by the involvement of nurses at the initial design and testing stage. However, achieving such alignment and collaboration is not always easy. This study provided a clear warning of the potential consequences of nurses being reactive rather than proactive, whereby decisions about robots in nursing may be made by others. More than a decade ago, Forbes and While (2009) argued that nurses were not involved enough in the development and deployment of new technology and urged them to take an active role in shaping electronic care systems. More recently Papadopoulos, Koulouglioti and Ali (2018) and Bulfin, Grobbel and Fuller (2019) all asserted the imperative that nurses be directly engaged in the design, implementation, and evaluation of robots.

Examples from the implementation of other technological systems such as electronic patient records systems illustrated an absence of nursing involvement. This is despite the significant changes these systems make to the day-to-day life of nursing staff (Forde-Johnston, Butcher and Aveyard, 2023). Hamer and Cipriano, (2013) suggested this was due to an embedded belief that nurses are too slow to embrace new technologies and are disruptive or even obstructive to change. Consequently, nurses are excluded, cost may be prioritised over functionality (Dykes and Chu, 2021) and testing may lack rigour as in Han, Kang and Kwon (2017)'s evaluation of a Total Nursing Robot System.

Historically, nursing resistance has been documented, although examples often related more to poor design leading to resistance to use, rather than resistance to technology per se' (Timmons, 2003; Kossman and Scheidenhelm, 2008). Either way, this can be a costly implementation challenge as Staggers *et al*., (2011, 2018), identified when two-thirds of staff abandoned an electronic tool, preferring its paper predecessor. Conversely, Kent *et al.,* (2015) identified the benefits of a successful nursing data collection tool through user involvement and testing.

However, in order to contribute, nurses need to be prepared and Dykes and Chu (2021) suggested this should start during nurse education with students being taught about technology design and selection. Bulfin, Grobbel and Fuller (2019) went further, arguing that nurses have a professional duty to collaborate in designing and employing high-quality, cost-effective technological products. Tietze and McBride (2020) attempted to formalise this on behalf of the American Nurses

Association by advocating the allocation of industry-based financial support for nursing involvement in the development process.

Nursing involvement in robot design, testing and procurement is key to the development of relevant and useful robots. One solution may be to develop new roles, such as robot developer, designer or engineer. Interestingly DuQuesne University, despite having a questionable website on nursing robots, have developed a hybrid nurse engineer programme (Glasgow *et al*., 2018) which could support this. Nurses need to overcome any reluctance and take the opportunities to be 'at the table' and involved in robotic development from inception, through rigorous testing before procuring robots for practical use.

9.6. Developing nurses' technology proficiency

In addition to involvement in design and testing, nurses need to be able to use robots proficiently if they are to harness the benefits of the technology. Booth *et al*., (2021) argued that when nurses don't keep up with advancements, it limits the potential benefits for both practice and patient care. Locsin (2017) referred to technical proficiency which accords with the proficient level of practice required for practitioners in a safety-critical profession like nursing (Leary 2023). According to Benner (2001), proficiency is the level beyond competence characterised by mastery and confidence developed through time and experience and learning from others. This is interesting, as often in nursing the focus has been on competence (certainly at the point of registration (NMC 2018b Annex B), which for robots may be the level where nurses can use the machine or the robot safely. Proficiency, however, may refer to the level of confident use, where benefits such as time-saving, or greater quality can be realised.

Developing proficiency involves preparing nurses with the knowledge, skills and behaviours to use robots. While and Dewsbury (2011) referred to knowledge, suggesting that exposing nurses to technology equips them with a better understanding. This builds on Dykes and Chu's (2021) suggestion that preparation should start during nurse training. Brennan and Bakken (2014) considered knowledge and skill development, advocating the development of a critical mass of practitioners to understand how to use data science to create nursing knowledge. This is useful but needs a wider focus to include assistive technologies such as robots. Pepito and Locsin (2018) referred to the behaviours of savviness and courage to lead the development of new patient care models enabled by digital technologies, which corresponds to my personal insights about problem-solving and creativity being key skills for robot adoption in Japan.

Developing proficiency also involves ensuring that novice nurses are developed and supported to develop mastery in nursing. Mastery in nursing is not just about what nurses do and why they do it but also about when nurses choose not to follow a path or support an intervention. Mastery in nursing was defined by Sharma (2016) as combining four elements: learning; knowledge; critical thinking and a developer mentality each of which is learnt in practice and supported by role modelling and education from experts in nursing.

Given that robots are not nurses, and cannot have desires, robots can have no desire to master nursing and it is therefore imperative that the education of nurses continues to be led and delivered by those that can master nursing (i.e. nurses). There is already considerable concern that artificial intelligence will replicate the same biases created by biased humans in the past (Cho, 2021). The same could occur in nursing if taught by non-humans and it follows that academic leaders and healthcare providers must retain expert nurses - ‘nursing masters’ - to teach nurses.

Such nursing experts need to be able to role model the visualisation of the whole picture for patients, clients, loved ones and the environment. The alternative is stark, and nurses' perspectives confirmed the declaration by Bulfin, Grobbel and Fuller (2019) that…

> "*we must be mindful that nursing is more than a series of programmable functions [but] rather lived experiences are shared between the nurse and those being nursed*".

However, to date, there is no requirement for digital competence or proficiency mandated for nurses in the UK. In America core competencies are in place for nursing education, explicitly identifying informatics, social media, and emergent technologies and their impact on decision-making and quality as critical to professional practice (American Association of Colleges of Nursing, 2021). However, the same is not true of the UK where the NMC (2018b) Standards of Proficiency for Registered Nurses (Annex B) included just one reference to digital technology which relates to keeping digital records.

Currently, neither the NMC Standards of Proficiency (2018b) nor the NMC code (2018a) require technological proficiency so need updating. This translates to a lack of a mandated requirement for UK Universities to include technology proficiency in their curriculum design and means that nurses may continue to be unprepared for a future which includes technology or robots. Such an absence may also perpetuate the somewhat naive fears of job losses voiced by RNs in this study.

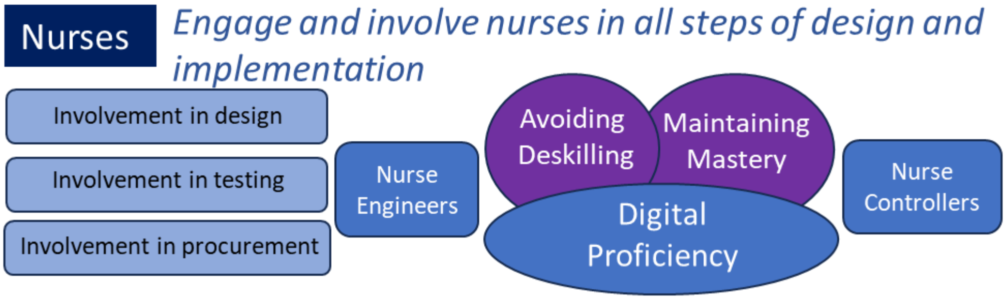
Therefore, key policy organisations such as the NMC and the RCN should look to include technical proficiency as a fundamental skill in future guidance. Importantly technological proficiency cannot be limited to information technology but will need to specifically consider the role of robotics in nursing.

As technology becomes an integral part of nursing delivery, the accountability for patient safety and decision-making should also be further elucidated. This will come into sharp focus, if and when judgement and decision-making as to the deployment of a human or (in the future) a robot, becomes a nursing responsibility. It would follow then that preparation for this responsibility should be included in professional standards. Current standards also do not make reference to any form of delegation to a machine or a robot, referring to other persons only. Although one might argue that machines have not to date featured in professional codes, as machines become autonomous, this will be a necessary consideration.

9.6.1. New roles for nurses

Having identified the role that robots might undertake, it follows that these might change the nature of nursing and impact on the role that nurses play (Bulfin, Grobbel and Fuller (2019). Casting robots in the role of assistant technology reciprocally casts the nurse in the relationship of robot operator. This is particularly true of teleoperated robots and moving and handling devices and underpins the prerequisite of comprehensive training. Similarly, findings from this study assert the desire for nurses to retain control of robots which means that nurses will need to adapt their role to become decision-makers in robotic deployment and supervisors of robotic care. Furthermore, one of the concerns nurses raised was the likelihood of robot malfunction and the nurse’s role in managing breakdown. Some suggested that nurses would need to be trained to troubleshoot and others suggested that 24-hour access to a technical resource was imperative. Whilst the former will likely be necessary at a basic level, robotic complexity (and wider technology use) will likely necessitate resourcing the latter in the future. It may also be that sourcing technicians may be easier than equipping enough nurses with the detailed technical capability required. However, each new role for nurses suggests a programme of knowledge and skills acquisition that needs to be added to the educational preparation of nurses in the future. The development of nurses has been illustrated graphically below in Figure 9.3.

Figure 9.3. Nurses Development Opportunities



9.7. Developing nursing

Existing frameworks and checklists designed to support technology introduction invariably omit to consider the impact on professionals and the profession, both of which are crucial for sustainability i.e. Beer, Fisk and Rodgers (2011) and Rizvi, (2022). The need to continue to develop nursing as a safety-critical profession therefore must run alongside the introduction of robots so that a sustainable approach can be built. Figure 9.4. illustrates a number of factors to be considered in developing nursing.

Figure 9.4. Development of Nursing

9.7.1 Nursing theory

The introduction of robots to nursing promises to be so significant that the theoretical framework underpinning nursing may need to be reconsidered. Tanioka, Locsin and Osaka have each developed complementary new nursing theories to support a different nursing future. Their respective mid-range nursing theories will now be considered in the context of this study.

Tanioka's (2017), Transactive Relationship of Nursing Theory (TRETON), presented a model to guide nurses' engagement with both healthcare robots and human patients. His theory proposed that all relationships, regardless of whether they involve humans or intelligent machines, are essentially transactional. However, a focus on the purely transactional somewhat understates the complex thought processes involved in nursing and restricts nursing care to simply completing tasks. Furthermore, this also contradicts Tanioka's own emphasis that nursing care extends beyond task completion. Tanioka acknowledged the nurse's ultimate responsibility for tasks performed by the robot but proposed a triad relationship between the robot, nurse, and patient, with the assumption that the intelligent machine is capable of some autonomous practice. Visual representations of this theory placed the intelligent machine at the centre of the nurse/robot/patient relationship, representing a departure from UK requirements for a 'Patient-Centred Care' equivalent (NHS England, No date).

Tanioka (2017) posed six questions, the first of which called for healthcare and nursing to be defined (similar to this study). The second question asked 'Should robots be humanoids?' Roboticists in this study argued strongly that robots should not always be conceived as humanoids and the pictures in the taxonomy developed for this study were adjusted accordingly in phases 2 and 3. Tanioka's third question related to discerning the functions necessary for robots to perform their delegated tasks which in this study were identified as monitoring, moving and handling, fetching and carrying and record-keeping /sharing information (in common with other studies). In questions four and five Tanioka proposed two alternative roles - assistant and partner - and questioned the level of robotic intelligence required to undertake these roles. In this study, the roles of responsive runner and advanced machine, and the helpful co-worker role compare to Tanioka's assistive role. Chapter 8 also discused a higher level of robot, the proxy nurse-bot which is comparable to Tanioka's partner role. Tanioka's final question asked about ethical issues and a number of nurses also discussed or alluded to ethical considerations in this study. Conceptually the assumptions about the role of patients in TRETON do not align with British nursing and the classification of robot as a partner is unlikely to be accepted in the light of this study's results. However, the six questions constitute a useful starting point to develop a theoretical decision-making framework for considering robots.

Osaka (2020) developed the Model of Intermediary Role of Nurses in Transactive Relationships (MIRTH). Aiming to complement the TRETON model, she placed the nurse at the centre of the relationship with the patient and robot on either side of the nurse. Osaka (2020) asserted that the nurse's role is to advance the technology and enable the '*value of the robot therapy to be enhanced'*. It is possible that some of the nuances of this intermediary role have been lost in translation, but whilst advancing technology may be part of a future nurse's job, the primary role of the nurse is to focus on patient need, not on the advancement of technology. Osaka's focus on technology before patients would therefore be at odds with UK nursing requirements to prioritise patients (NMC 2018a). The change in the nurses' role to that of *'intermediary'* is also in direct contrast to findings in this research where nurses saw themselves in control of robots. However, whilst the terminology of intermediary may not be helpful, it is important that the nurses' role is clear, be it technology deployment manager or robot controller.

Locsin's (2017) 'Technology as Caring' theory suggested that nursing care could be provided by autonomous robots in the future which is refuted by the data in this study. Locsin (2017) outlined five dimensions of technology to categorise their functions from technology that enhances human abilities, such as artificial limbs, through to the fifth dimension which predicts a future where human and technological cells are combined into a chimaera. However, this classification appeared to be a stand-alone concept rather than a model for nursing practice.

Locsin (2017) postulated that in the future autonomous robots will play a role in the nursing field, transforming the practice of nursing in three ways: technical knowledge, mutual design, and participatory engagement. Technical knowledge involves using technology to better understand patients and emphasises the idea that nurses demonstrate their care through technical proficiency. This concept of technical proficiency has also been endorsed in the UK (Topol, 2020; NHS Long Term Workforce Plan, 2023) and would therefore seem a worthy goal as discussed earlier in section 9.6.

Mutual designing was explained by Locsin (2017) as being the process of the nurse and patient designing a process of care together. There were numerous references to patient consent and patient involvement in care needs in this study and a co-designed process would appear to be pivotal should a robot be part of the delivery whereby the nurse negotiates or agrees the appropriate level of robotic involvement with the patient. However, Locsin (2017) believed in the long term that as artificial intelligence advances, robots could replace human nurses in the process. Nurses in this study emphatically rejected future substitution which reinforces the need for clear policy direction as discussed in section 9.4.

Locsin (2017) identified participative engagement as the third aspect of nursing, which involves delivering care through mutual activity. Locsin envisioned a future where robots with artificial general intelligence take on the role of nurses, leaving the nurse's role undefined. However, whilst this aligns with the 'feared substitute' in this study, this theory was not supported by data in this study and also contradicts Tanioka's (2017) assertion that nurses will still be responsible for robot activities.

In summary, these mid-range theories and Locsin's (2017) in particular, commendably attempt to conceptualise nursing in the long-term future, when artificial general intelligence is in place, and robots have the capability to substitute for human nurses and ostensibly become the new "nurse". Schoenhofer (2017), who co-authored the Nursing as Caring theory, praises Tanioka and Locsin for their efforts to advance caring practices into the future. Findings in this study support Schoenhofer's (2017) conclusion that the future still includes "*nurses as we know them today*," alongside robots (p. iii) which appears to contradict the postulations of both Locsin and Tanioka (2017). These theories do, however, give a nudge to anyone who is questioning that technology is an inevitable part of the future of nursing.

Two important questions arise from the consideration of these theories. Firstly, do they help nurses provide knowledgeable and consistent care, and secondly can adopting these theories help nursing prepare for the future? The first is unknown and the theories themselves can be difficult to comprehend which may impede adoption. However, whilst this study's results contradict some of Locsin's (2017) key assumptions, his model does contextualise the findings in this study, as he considered the long-term timeframe of 2050 and beyond. In terms of helping nursing prepare, Locsin (2017) polarised a view of the future that nursing must either accept or reject and at the very least shape. Therefore, there is also a need to refine and develop nursing theory so that it can assist nurses to carry out their nursing work in the context of technological advancement.

Bulfin, Grobbel and Fuller (2019) described it as a moral duty to engage with this technology to ensure robotic care complements not replaces nursing care. Others would agree, particularly van Wynsberghe, (2015) who argued that just because something can be done (i.e. robots have capability) does not mean it should be done (i.e. robots substitute for nurses). However, given the shortage of nurses, it must also be a moral duty to engage with opportunities that might mitigate the risks of this. Locsin and Ito (2018) argued that in order to consider the future of robots in nursing we need to be clear on the unique contribution of nursing. Interestingly the NMC professional standards (2018a) also do not require nurses at the point of registration to be able to articulate succinctly what nursing is and what the unique contribution of nursing is, which perhaps explains why this is so poorly understood.

This study illuminated a perception of fragility within the profession, such that its potential is easily usurped by considering the introduction of robots. If nursing is to harness the potential that robotic technology offers, nurses will need to be able to define what nursing is. Yet defining what nursing is, is not an easy task.

9.7.2. The Unique Contribution of Nursing

Articulating what nursing is and what it contributes is particularly important in the field of robotics where nursing is frequently conflated with social care or described as a set of tasks. This undermines the skill of nursing and the safety-critical nature of the profession (Hollis, 2021). Participants in this study referred to the complexity of nursing and the distinction between complex and complicated. Complicated, according to Greenhalgh *et al.,* (2017), consists of multiple interacting components or issues), and is something robots may do well. Complex, however, relates to issues that are dynamic and unpredictable and not easily disaggregated into their constituent parts (Greenhalgh *et al*., 2017). The complexity of nursing is found in the multiple judgements of fluctuating stability with overlapping steps and processes, overlaid with multiple and sometimes opposing requirements. Human nurses develop expertise in dealing with this complexity to find the individualised solution that best suits each patient. Thus, the unique contribution of nursing could be articulated as providing a tailored, personal solution to every patient and having the expertise to know what is needed and when. To take the terminology used by roboticists, nurses have expertise in dealing with a population of 'edge cases'.

9.7.3. Avoiding reductionism through a safety-critical focus

There was a clear steer in the nurse leaders' focus groups to avoid reductionism when considering robotic involvement. Maxwell and Leary (2020) suggested that reductionism in the form of the division of labour is a common response to the intractable challenge of more complex demand with a deficit of hands and skills. However, Leary (2023) argued that healthcare is 'high harm potential work'. At its worst, reductionism results in an approach to workforce planning where the most vulnerable (patients) are looked after by the least experienced; *'the rookie factor'* as Leary describes it (Leary, 2023). This approach runs counter to safety-critical industries where the most experienced are deployed to the area of safety happenings and are skilled at handling surprises (Leary, 2023). In this study too, nurses raised concerns about deskilling.

This is critically important when considering the introduction of robots. A Taylorist model where work is divided into tasks might be suited to high volume, less complex, discrete tasks but can lead to safety failures (Maxwell and Leary, 2020), and in complex, high-risk work, that failure can often be catastrophic (Leary, 2023). Leary (2023) also argued that in safety-critical work the interface between tasks is the riskiest which concurred with insights from my travel fellowship.

One of the key skills enabling nurses to keep patients safe is their surveillance abilities or vigilance. It is crucially important that robot introduction maintains nursing skills and does not impair the ability of nurses to sustain their cognitive skills including surveillance, vigilance, perception of risk, recognition of concerning deviations, clinical judgment in order to rescue patients when needed (Klenke-Borgmann, Lineberry and Broski, 2023). Robots may be able record vital signs or categorise facial expressions but such task allocation, without interpretation or the ability to intervene and rescue, could pose risk. It follows then that nursing supervision must be considered as if robots are to be supervised by nurses, the impact on their nurses' vigilant capacity must be considered taken into account.

It is known that capacity for vigilance reduces as demand increases (Leary, 2023). Therefore, it is crucially important to consider how the introduction of robots might enhance and enable nurses to exercise their vigilance and rescue skills. It is possible that autonomous robots may better enable nursing capacity through a distributed model of workforce planning but nursing needs to embrace and guide the opportunity in order that robot assistance enhances rather than endangers care.

9.8. Chapter Summary

This chapter discussed the results of the study in the context of the research literature and theoretical literature related to technology acceptance and technology in nursing. Perspectives that robots will be a part of the future were discussed and the need for nurses to be engaged and involved in shaping the future was strongly argued. The chapter identified the new knowledge contributed by this study which was summarised in Table 9.1. and proposed a number of developments to guide future action comprised of an approach to policy development, robot development and deployment, preparation of nurses and development of the nursing profession. The conclusions and recommendations will now be considered in the final chapter.

Chapter 10. Conclusions and Recommendations

10.1. Introduction to the chapter

This concluding chapter of this thesis will consider how each chapter contributed to the aims of this study and answer the research question. The strengths of the study will be considered and a summary of new knowledge presented prior to consideration of the limitations of this study. Conclusions drawn from the discussion in Chapter 9 will be restated and recommendations for the next steps will be identified.

10.2. Summary of the Thesis

This study explored the potential role of robots in nursing care. Chapter 1 introduced the challenge facing the nursing workforce and presented the research question and situated the study within the context of strategic nursing leadership. Chapter 2 provided background on nursing and relevant theories. Chapter 3 explored the literature related to nurses' perspectives highlighting a need for future-oriented research. Chapters 4 and 5 explained the social constructionist approach, the theoretical background, and the methods for data collection and analysis during each of the three phases. The study's design was iterative, using insights gained from interviews with roboticists to inform the expectations of registered nurse participants, and presenting the perspectives of registered nurses to chief nurses and thought leaders. Chapter 5 concluded with a discussion on research quality and a reflexive overview of the study.

The first of the results chapters, Chapter 6, presented the framework analysis of five interviews with Robot developers or roboticists, addressing the first objective of the study. It was concluded that robots can assist nurses in the next 10-15 years but are unlikely to replace nurses in the next 50 years due to technological constraints and the complexity of nursing.

Chapters 7 and 8 addressed the second study objective by exploring and analysing nurses' perspectives on what might be acceptable and appropriate roles and activities for robots. Chapter 7 presented the RN's perspectives which include a general acceptance of robots performing activities such as lifting and handling, monitoring vital signs, and courier tasks and their hesitancy about tasks that might require human judgement or involve risks to patients such as patient feeding or providing complex information. The different roles that robots might play in nursing were presented as six distinct roles conceptualised through the combination of nurses' descriptions of activities and their perceptions. Most nurses found the roles of "advanced machine," "social companion," and "reliable runner" to be acceptable, while the role of "helpful co-worker" received mixed support. However, the conceptual roles of "proxy nurse-bot" and "feared substitute" were not supported as they replaced some or all aspects of a human nurse.

Three crosscutting themes were presented from RN focus groups: fear of what the nursing future might hold; a negotiated reality of a future shared with robots, and a positive opportunity. These themes illuminate the factors that might help or hinder robotic use in the delivery of nursing care meeting the third objective of the study.

Chapter 8 presented the results of nurse leader focus groups, categorised into four themes: initial impressions of robots in nursing, the essence of nursing, the need for debate, and reframing of the future as 'robots can assist'. These themes contribute to the study's fourth objective of identifying the role that robots might play, by proposing a supportive role in delivering hospital nursing. The chapter also identified a clear appetite for nurse leaders to lead discussions, address substitution concerns and reframe the role of robots as assistive.

Chapter 9 discussed the principal findings in the context of literature including theories of technology acceptance and technology in nursing. The chapter proposed the next steps for policy development, robot development, nurse preparation and considering the impact on nursing as a profession. These next steps address the fourth study objective and the enhanced insight and new knowledge generated by the study was presented in Table 9.1.

This tenth chapter will now consider the strengths and limitations of the study, before summarising the conclusions and presenting the recommendations.

10.3. Strengths and Limitations of the Study

In addition to this study yielding a rich spectrum of results, there are additional strengths to its validity, such as the use of an iterative phased approach which enabled results to be considered in subsequent phases adding to the relevance and depth of discussions. Secondly, the use of face-to-face methods to recruit registered nurse participants enabled direct observation of initial reactions. This combined with the advantages of the online recordings mentioned in Chapter 5 provided a helpful insight into how registered nurses might first react to robots. This reinforced the strength of using social constructionist methodology and in particular the use of focus groups. A number of participants indicated that they amended, changed or added to their initial perceptions during the focus groups confirming that perspectives were socially constructed during discussions.

This study also had a number of limitations and results should be considered in light of these. The main limitation is the non-inclusion of the perspective of patients and those close to them in the study design. Whilst some nurses referred to the patient perspective, it was not explicitly explored in this study and represents a missing part of the wider picture of robot acceptance in nursing. Whilst significant research relates to user perspectives in the home care and social care environments, future studies should explore the perspective of in-hospital patients and their visitors.

The second limitation relates to the qualitative study design and difficulties in recruitment and the consequent small focus group size and overall sample size. Generalisation of the results was not anticipated due to the qualitative design of the study, but the prolonged recruitment, multiple methods of recruitment and the 'no-uptake' from a large group of newly qualified nurses (Chapter 5) means more negative (or, albeit less likely, more positive) responses from newly qualified nurses may exist which have yet to be described.

A third limitation relates to the polarised nursing phases with just two phases of front-line registered nurses and nurse leaders included, which are not representative of the wide breadth and scope of nursing (even within a hospital environment). Whilst this was pragmatically necessary due to time constraints and the need for homogeneity of focus groups, it further limits assumptions about the wider transferability of results to the wider nursing workforce.

Fourthly the necessary use of online methods may have inhibited the depth of conversations between participants and certainly in some focus groups (particularly the larger ones) there was some evidence of serial contributions rather than between-participant discussion. Whilst there was the option for involvement in a face-to-face focus group, this was not taken up, and future studies could progress a face-to-face option more vigorously than was possible within the confines of this study.

Nurse participants were asked to complete an anonymous form to collect data to enable the study to report on how representative the sample was of the population. However, most participants did not complete this, which introduces a fifth limitation as data was not reportable and future studies - particularly mixed or quantitative studies, should give consideration to the importance of this.

The sixth significant limitation relates to the development of the taxonomy which despite it having a number of advantages over other taxonomies, was not formally evaluated and tested in this study. Given that it was well received, a further study – perhaps in the form of a Delphi study - could refine and validate its utility.

In summary therefore several methodological limitations have been identified with this study which could be strengthened in future studies. The conclusions from Chapter 9 are summarised below as they relate to the four aims of the study (section 1.8 of this thesis):

Aim 1. To propose likely scenarios of robotic capability, identifying likely technological constraints.

1. Robots will not replace nurses in the next 10-15 years but could assist
2. The taxonomy is a helpful tool to guide future discussions
3. Human warmth, empathy and compassion are important aspects of nursing not easily replicated by robots
4. Useful areas of robotic development would be reducing/ addressing patient falls, translation services, improving the safety and resilience of robots and development of robots that act empathically and compassionately.

Aim 2. To explore and analyse nurses' perspectives on what might be acceptable and appropriate roles and activities for robots in nursing.

5. Nurses would accept the introduction of robots in hospitals to assist with moving and handling patients, fetching and carrying (courier activities), vital signs recording and surveillance, medication dispensing and social support including patient education, and translation. In addition nurse would value administrative support with record keeping and information sharing.

6. Nurses would reject robotic assistance with empathy and compassion, maintaining privacy and dignity, and respecting values and beliefs.
7. Current technology in nursing theories are insufficient to guide nursing use of robots
8. The identification of six conceptual roles for robots aligned with acceptability for the next 10-15 years may assist in future discussion about how robots might function in nursing
9. Robot roles of advanced technology, reliable runner and social companion roles were most readily accepted.
10. Nurses perspectives were intrinsically linked to the perceived impact on them as nurses

Aim 3. To identify the factors that might help or hinder robotic use in the delivery of nursing care

11. Technology acceptance theory does not explain results: Positive and negative viewpoints may co-exist and fear, and autonomy need to be taken into account
12. Four pre-requisites are required for technology adoption:
    a) Nurses in control
    b) Troubleshooting procedures
    c) Gradual introduction
    d) Comprehensive Training

Aim 4. To propose how robots might contribute to the delivery of hospital nursing and make recommendations for the next steps.

13. Clear policy direction is needed on substitution versus assistive robots
14. The importance of nursing involvement in robot design is key to the development of relevant and useful robots and nurses need to be ‘at the table’ and involved in robotic development from inception to introduction to practice:

15. There are opportunities to develop new nurse roles of controller, designer /developer and possible troubleshooter.
16. Nurse leaders are supportive of taking a leading role in the debate and policy development on the role of robots, reframing the discussion to address the fear of nurse substitution by focusing on robots undertaking an assistive role.
17. The impact of robots on the profession of nursing is of crucial importance to nurses, nursing and the patients which nursing serves, and all nurses must engage with nurse leaders taking a proactive approach to shaping the future

10.4. Recommendations

Having detailed the conclusions, recommendations for next steps will now be considered in relation to robotic development, future research, nursing practice and strategic nursing leadership.

10.4.1. Recommendations for Robotic Development

This study found strong support for nursing involvement in the development of robots from the point of inception through to user testing. This first recommendation would avoid the time-consuming and ultimately wasteful development of technology that is not practical to use or which offers limited value.

In terms of artificial intelligence development, it is unlikely that general artificial intelligence that mimics human abilities will be accepted by nurses in the short term. However, views may change over the period of development and in the meantime the ability to translate both speech and written information into multiple languages and reiterate patient information messages are capabilities that would be valued by nurses. Therefore, developing these capabilities and those of robot development in responding empathetically and sympathetically should be progressed. In addition, the continued development of physical capabilities such as lifting and handling and courier capability together with extended battery life and resilience (to reduce or eliminate breakdown and malfunction) will be crucial to applications within hospital environments.

10.4.2. Recommendations for Future Research

The discussion of limitations earlier in this chapter provides a number of opportunities for future research to build knowledge in this developing area.

- Further research using a mixed method approach could explore if the findings in this study are generalisable to the UK nursing population and to other members of the nursing team is indicated. This would also continue the objective of future forming research by increasing awareness.
- Future research should seek to capture the perspectives of patients and those close to them (i.e. relatives, loved ones) in UK Hospitals.
- Further research should explore how robots might contribute to other branches of nursing and other settings such as community nursing (and particularly to virtual wards where they are established).
- Future focus group studies should more vigorously progress both face-to-face and online options when researching technology adoption
- Further research (particularly quantitative or mixed method) should give consideration to data collection to establish the representativeness of the sample.
- Further development, testing and research using the taxonomy through Delphi method to refine and validate its utility.

10.4.3. Recommendations for Nurse Education

The need for a review of nursing theory has been highlighted in this study by the consideration of the new mid-range theories of technology-supported nursing and by the use of the Fundamentals of Care framework to discuss and analyse the results. Therefore, it is recommended that:

- Academics and nursing theorists to consider if further development of mid-range nursing theory can support the delivery of nursing within a digital age

Nurse education is the starting point for developing the competencies, ethical frameworks and technological proficiency that will be needed for nurses to embrace technology including robots. It is recommended that:

- All nursing curricula should include technological and digital proficiency and problem-solving skills and the imperatives to prioritise care when using technology.

In addition, nurses need to be able nurses to articulate and debate the unique contribution of human nursing as this will equip nurses of the future to make sound decisions when considering the introduction of robots. An additional recommendation is therefore:

- Nurse education programmes should routinely include a focus on and the articulation and delivery of the unique elements of nursing (in particular the safety vigilance elements).

10.4.4. Recommendations for Practice

There is a clear need for nursing involvement in the future introduction of robotics from procurement through to implementation into practice, and nurses need to be prepared for this through the recommendations below:

- Developing professional standards that require the understanding and articulation of the unique contribution of human nursing and to requirement to promulgate the further development of nursing.
- Nurses need to engage in the design, development, testing, evaluation and procurement of robots at the earliest opportunity.
- Review and refine the navigational illustrations (Figure 9.1., 9.3., 9.4., and 9.5.) to provide practical guidance for future nursing decision-making.

10.4.5. Recommendations for Strategic Leadership

There was a clear appetite amongst the nurse leader participants to take the lead in future debate and policy direction and this was combined with a sense of urgency – the strategic leadership recommendations therefore represent the key priorities for implementation as follows:

- Addressing the substitution argument and asserting that the purpose of introducing robot roles must be to enable staff to prioritise clinical care reframing the opportunities for nursing to introduce robots to assist them and release time to care;
- mandating nursing involvement in the design, testing, evaluation and procurement of robotic solutions in nursing;
- referencing technological proficiency, digital competency and robotic control and deployment in policy documents (including NMC codes and standards);
- providing clarity about the role and boundaries and differences between human nurses and robotic roles;

- development of frameworks for considering the introduction of robots which include mandating the provision of 24-hour technical support and replacement technology when considering the introduction of robots;
- mandating conditional automation as the current limit for robotic assistance and review robot role boundaries every two years with Long Term Workforce Plan (2023) considerations.

These recommendations are summarised in Table 10.2. overleaf.

Table 10.2. Summary of Recommendations

Table of Recommendations from the study	
Robotic Development	1. Routinely involve nurses from the point of inception through to user testing 2. Development of robot capability in the following areas: • Progress robotic development in recognising emotion and responding in an empathetic and compassionate manner. • Continued development of physical capabilities such as lifting/ handling capability, courier activity and extended battery life /resilience.
Research	3. Further research using a mixed method approach could explore if the findings in this study are generalisable to the UK nursing population and other members of the nursing team. This would also continue the objective of future forming research by increasing awareness. 4. Future research should seek to capture the perspectives of patients and those close to them (relatives, loved ones) in UK Hospitals. 5. Further research to explore how robots might contribute to other branches of nursing and other settings such as community nursing (and particularly to virtual wards where they are established. 6. Future focus group studies should more vigorously progress both face-to-face and online options when researching technology adoption. 7. Further research (quantitative or mixed method) should consider data collection to establish the representativeness of the sample. 8. Further development, testing and research using the taxonomy through Delphi method to refine and validate its utility.
Education	9. All nursing curricula should include technological and digital proficiency and problem-solving skills. 10. Provide educational preparation to enable nurses to recognise, articulate and debate the unique contribution of human nursing. 11. Academics and nursing theorists should consider if further development of mid-range nursing theory is required if it is to support the delivery of nursing within a technological age.
Practice	12. Developing professional standards that require the understanding and articulation of the unique contribution of human nursing and to requirement to promulgate the further development of nursing. 13. Nurses need to engage in the design, development, testing and evaluation of robots at the earliest opportunity. 14. Review and refine the navigational illustrations (Figure 9.1., 9.3., 9.4., and 9.5.) to provide practical guidance for future nursing decision-making.
Strategic Leadership	15. At a strategic and policy level nurse leaders should identify a clear direction for robots in nursing which includes: • addressing the substitution argument and asserting that the purpose of introducing robot roles must be to enable staff to prioritise clinical care reframing the opportunities for nursing to introduce robots to assist them and release time to care. • mandating nursing involvement in the design, testing and evaluation of robotic solutions in nursing. • including reference to technological proficiency, digital competency and robotic control and deployment in policy documents about future nursing. • clarity about the role and boundaries and differences between human nurses and robotic roles. • The development of frameworks for considering the introduction of robots which include mandating the provision of 24-hour technical support and replacement technology when considering robotic introduction. • mandating conditional automation as the current limit for robotic assistance and review robot role boundaries every two years with Long Term Workforce Plan (2023) considerations.

10.5. Closing statement

This study set out to explore the potential role of robots in nursing and found evidence to support their use as assistants to nurses in providing quality care. This study also considered the broader question of whether robots will become a common practice in nursing care, and the consensus was found to be affirmative. However, for this to become a reality, nurses need to take an active role in shaping the future of robotic solutions that aid and complement their work. This will rely on strategic leadership to keep patient needs central, a clear vision and understanding of the unique contributions of nursing so that nurses can judge when and where to deploy their technological proficiency and harness robotic developments to improve the delivery of safe, empathetic and effective care and when to rely on human expertise. Nurses must harness the opportunity to use robots in nursing where they can improve care and enable their safety vigilance to protect patients. Conversely nursing must resist deployment and protect their profession where robots do not enhance or support care. Robots are a future reality for nursing and nurses at all levels must engage, navigate and oversee their contribution to the future.

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Appendices

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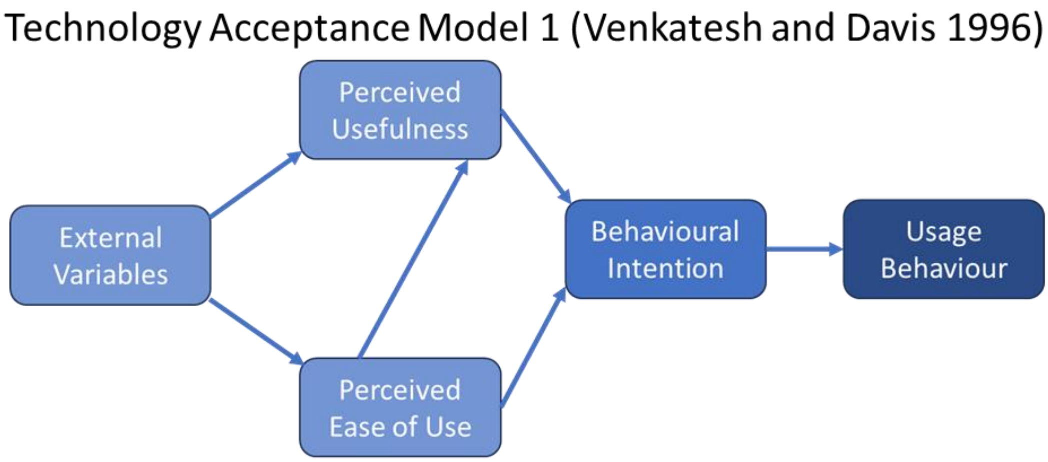
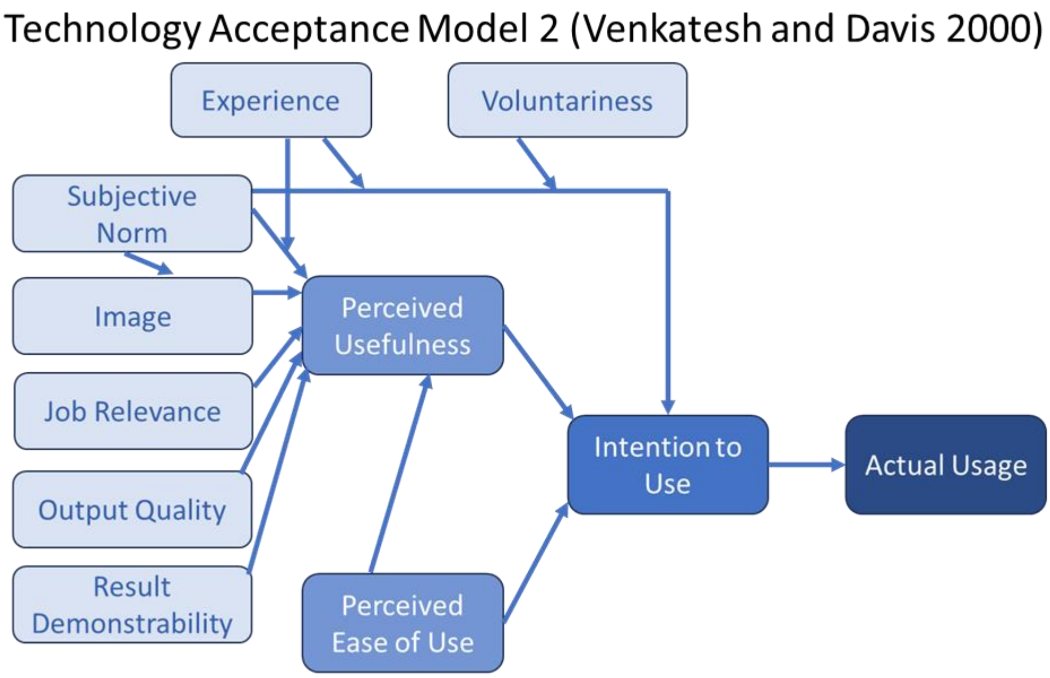
Appendix 1. Individuals and Insights from Winston Churchill Travel Fellowship

Summary of individuals and insights by location of the Travel Fellowship

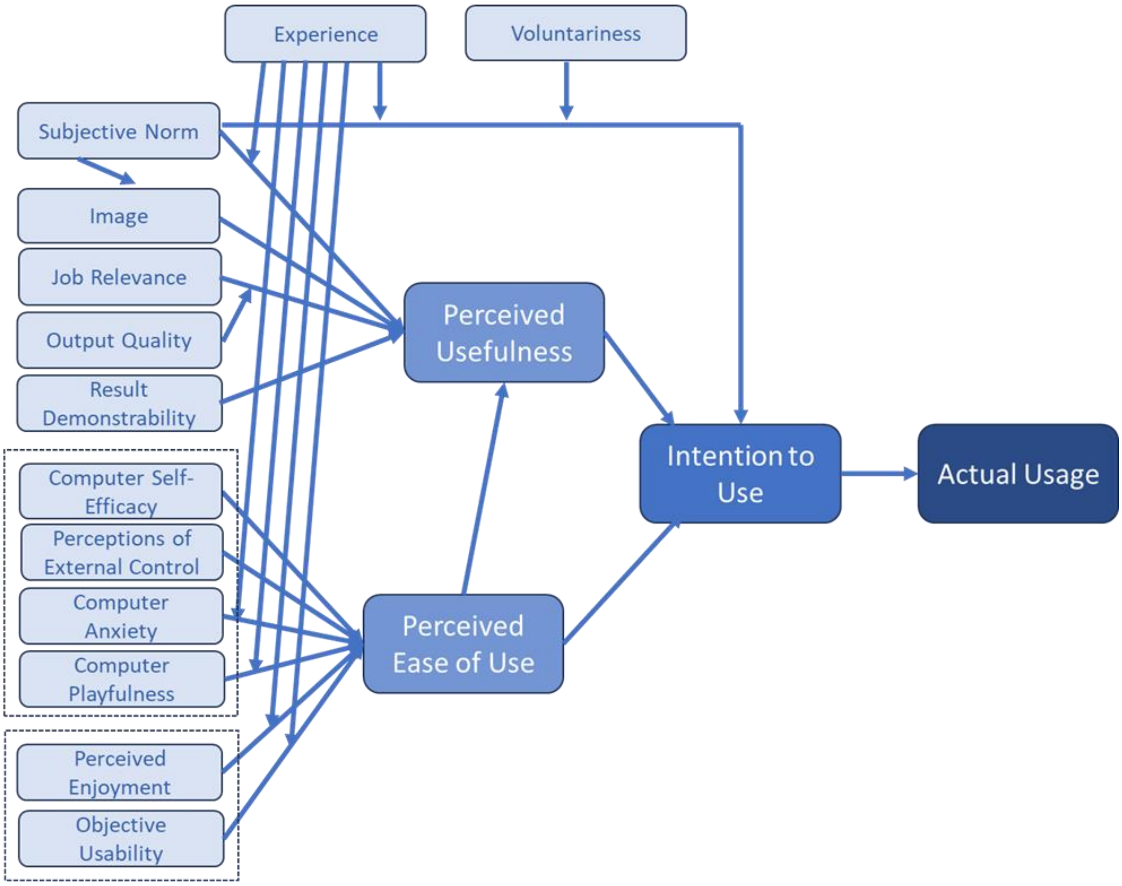
Winston Churchill Travel Fellowship: Individuals visited			
Place	**Country**	**Key Individuals**	**Key Insights**
Macau IROS Conference	China	Dr Kirsten Grauman Dr Chris Harper Associate Professor Xiang Li Professor Stefano Stramigioli Associate Prof Gentiane Venture, Dr Richard Hawkins	1. How machines learn 2. Robots cannot replace nurses 3. Robots can anticipate human action 4. Robotic physical capability limits robot development 5. Clinicians and Robots learn from aberration 6. Humans are the comparators for safety and accuracy. 7. Handover is greatest area of risk 8. Levels of Automation
Tokyo AIST AIST Human Augmentation Research Centre AIT Zenkoukai Care Facility	Japan	Dr Hiro Hirukawa Dr Yoshio Matsumoto Takashi Miyamoto Associate Professor Gentiane Venture	2. Robots cannot replace Nurses 9. Definition of a robot 10. Robotic Development must be resilient 11. Flexibility and creativity capabilities influence technology adoption 12. Sensors are available now and could make a real difference 13. Human to Robotic interaction can increase human to human interaction
Adelaide Flinders University Flinders Medical Centre	Australia	Dr David Hobbs Associate Prof Chris Barr Professor Robyn Clarke Professor Anthony Maeder Professor Alison Kitson Dr Rebecca Feo Associate Prof Pauline Hill Associate Lecturer Shelly Abbott, Placement Education Coordinator Leeanne Pront Senior Lecturer Katrina Breaden Graeme Alcock, Loris Glass	13. Human to Robotic interaction can increase human to human interaction 14. Technology development must be done with clinicians 15. The role of Avatars 16. Future focus on a type of technology and impact 17. Fundamentals of Care 21. The value of the Churchill Fellowship
Auckland University of Auckland. Middlemore Hospital Auckland Hospital	New Zealand	Dr Jenny Parr Professor Bruce MacDonald Kathy Peri Dr Julia Slark	18. Role of relationship and risk in care 19. Physical design of robots assists interaction 20. Student preparation for the future

Appendix 2. Technology Acceptance Model 1 & 2 & 3



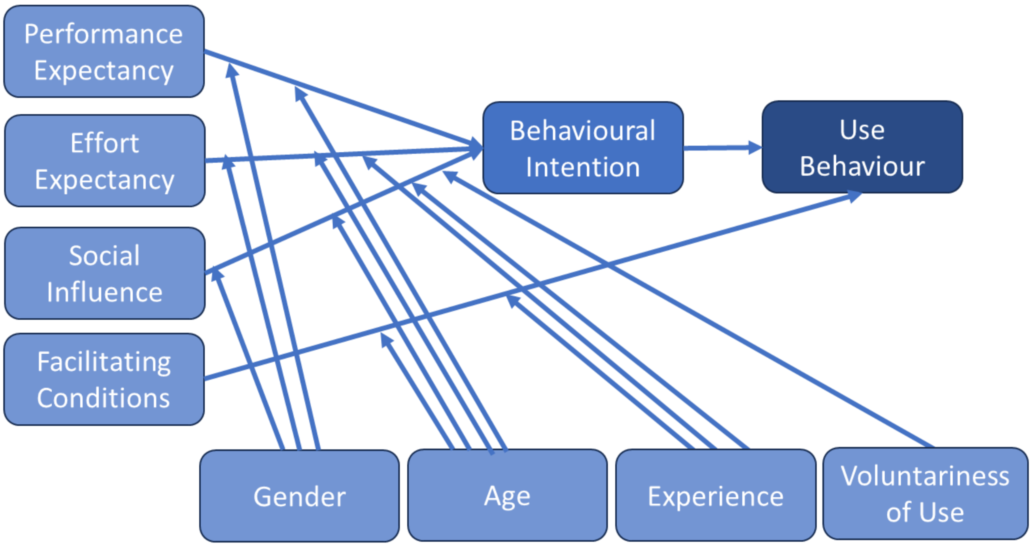


Technology Acceptance Model 3 (Venkatesh and Bala (2008)

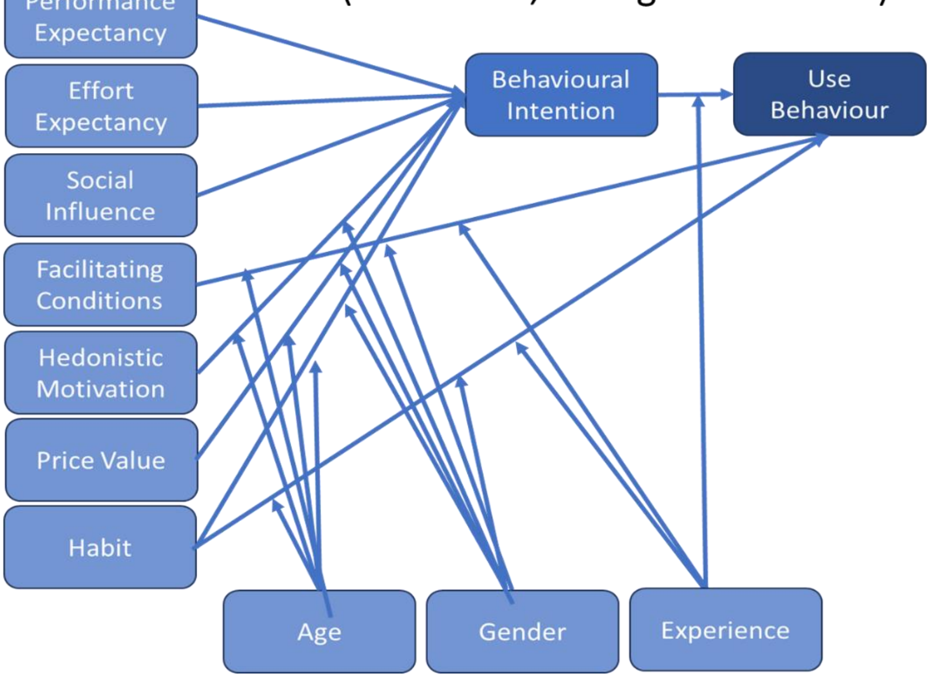


Appendix 3. Unified Theory of Acceptance and Use of Technology

Unified Theory of Acceptance and Use of Technology 1
(Venkatesh et al 2003)



Unified Theory of Acceptance and Use of Technology 2
(Venkatesh, Thong and Xu 2012)



Appendix 4. Protocol for the literature review

Literature Review Protocol

1. **Rationale:** To identify research literature focused on the role of robots (with varying degrees of autonomy) in the delivery of nursing care in hospitals.
2. **Aims:** The aim of the literature review is as follows (Drawn from Peters *et al*., 2015):
   - Clarify key concepts such as robot, service robot, nursing robot, companion robot and social robot
   - Systematically search a broad area of evidence across nursing, electrical engineering and robotic development
   - Identify the gaps in the knowledge base
   - Report on the type of research and theoretical evidence available
   - Report on the research methods and what this might mean for this UK nursing study.

3. Literature Review Questions

- What do we know about nurses' perspectives/attitudes to robots in hospitals currently?
- What is the quality of this research and what gaps might there be?

4. Working title:

Nurses' perceptions of robots in hospital nursing – an integrative review of quantitative, qualitative, theoretical and practice literature. (NB this differs from the research question as not limited to a future time frame and doesn't specify therapeutic nursing care).

5. Definitions:

Four keywords or concepts were included in the search criteria: Hospital, Robot and Nursing and Perspectives, the definitions for which are described below:

Definitions for Literature review			
Robot	Nursing	Hospital	Perspectives
Robot will be defined as a technological object or machine with capability to move, sense and process information and act on the environment.	Care delivered by nurses or under the supervision of nurses or the practice by a nurse of providing care to a patient	An inpatient care facility employing nurses	Views, Attitudes, Opinions or quotes

6. Methodological Approach (Search Process)

6.1. Initial scoping searches (analysis of text words in title and abstract in one database) were undertaken in the CINAHL database searching on robot* AND Nursing OR healthcare

6.2. A second set of searches using the narrowed search terms of Robots* and Nurs* was undertaken across four (CINAHL, BND, Pubmed and IEEE) databases searching on Nurs* and Robot* in the Abstract and Title.

6.3. Cross check of key papers to make sure they are picked up by narrower search terms

6.4. Snowballing of references from all selected studies and all previous scoping or literature reviews was conducted and records review.

6.5 Add results to Preferred Reporting Items for Systematic Reviews (Moher 2009).

6.6. Conduct Grey literature searches: EBSCO, EThOS, and NDLTD using the terms Robot* AND Nurs*. Results are shown below (the EThOS database yielded no results but searching on "Robots AND Nursing" found 4 results.

Database	Records found (titles reviewed)	Review of Abstract
EBSCO	27	0
EThOS	4	0
NDLTD	126	3

7. Review Process

7.1. All records found reviewed by title and records not relevant to study removed i.e. records pertaining to nurseries, robotic-like behaviour and robotic surgery.

7.2. Records combined and duplicates removed using End Note

7.3. Record abstracts reviewed against the inclusion and exclusion criteria and records related to surgical robots, exoskeletons for rehab, social robots (non-hospital settings), social and community care settings, and non-research papers removed.

7.4. Full text review and records removed that did not include nurses' perspectives, were not research or were related to product testing rather than nurses' viewpoints.

7.5. All literature reviews and selected papers read in full and reference lists added to snowballed list and titles reviewed against inclusion/exclusion criteria.

7. 6. Review process was repeated in July and alerts were set up on search terms on each database.

8. Selection Criteria

The table below identifies the inclusion and exclusion criteria for the literature review and gives the rationale for each.

Inclusion and Exclusion criteria for the Literature Review		
Inclusion	**Exclusion**	**Rationale**
Literature related to perceptions, attitudes and preferences for robots in hospital nursing	Studies where the majority of participants are not nurses or where nurses perceptions are not included	The key focus of this study is focused on the perspective of nurses
Literature related to robotic delivery of nursing care in order to assist or improve the delivery of nursing care	Literature related to medical and operative robotics	Peri-operative robotics are teleoperated robots –so low degree of robotic autonomy, operated by doctors and not related to delivery of nursing care
Telepresence robots in nursing ie assessment/ communication from a distance	Telepresence robots for medicine – remote consultation	Telepresence robots may assist with the delivery of non-physical nursing care but exclude medical consultation
	Telepresence robots used for nursing education purposes	Relates more to education rather than nursing practice
Socially assistive robots in a hospital setting where nurses perspectives are explored	Socially assistive robots in homecare and social care settings Social Robots: Exclude unless abstract indicates the impact on nursing provision or patient acceptance	Important to review abstract to get an overview of capability but exclude if only impact explored is social and not nursing care or if nurse perspectives not included. Social robots may not be relevant to delivery of nursing care but reading the abstract gives an overview of social capability as some authors do not distinguish between nursing care and social care
Robotic exoskeletons used by patients for mobility or nurses as Robotic Lifting devices		This may be an area of robotic development relevant to nursing
	Robotic patients used in nurse education	Education Robotics are usually teleoperated and aim is to provide a lifelike patient for clinical practice
	Robotic Pharmacy – Automated Dispensing Cabinets	Robotics are limited to storage or dispensing medication and not to the administration of medicines. Dispensing cabinet is not defined as a robot
Literature related to wider technology adoption in nursing	Literature related to technology that doesn't include robotics or robots	To focus the review towards autonomous robots
Full paper available in English		To be able to access the article and understand the meaning (translation software can help but the meaning is often less clear)

9. **Data Extraction:** For each study the following data was extracted

Title	Year	Authors	Authors background
Study Purpose/ RQ	Number of Participants	Population	Sample
Study Method	Definitions	Country	Analysis
Findings	Conclusions	Limitations	Additional Limitations

10. Quality Appraisal

Whitmore and Knafl (2005) emphasise the importance of assessing the quality of the studies, and the aim of the quality appraisal was to give an indication of the limitations of the current research literature, rather than to use the quality appraisal to exclude some research papers on the basis of poor quality.

It was important that quality appraisal criteria could accommodate both Qualitative and Quantitative studies and the Framework developed by Kangasniemi, Karki and Voutilainen 2019 was used as it provided an integrated overview of both qualitative and quantitative literature. This framework drew from the work of Caldwell, Henshall & Taylor (2011), Gifford, Davies & Lybynon (2007) and Greenhalgh *et al* (2004). Each of these sources was reviewed and additional elements were added: including the definition of concepts and evaluation of generalisability and transferability. The quality appraisal criteria were used to aid the better understanding of the research and its strengths and weaknesses, rather than to exclude papers on quality grounds.

Quality Appraisal Questions
Does the title reflect content?
Are Authors Credible?
Was rationale for research clearly stated?
Were Aim and Objectives of Research clearly presented?
Was theoretical framework/literature review comprehensive?
Was background up to date?
Was study design appropriate for research question?
Was methodology clearly identified?
Was methodology clearly justified?
Were ethical issues clearly identified and addressed?
Was ethical approval sought and received?
Was informed consent obtained?
Were results presented in a clear way?
Was the discussion comprehensive?
Were the conclusions clearly presented?
Were the conclusions comprehensive?
Was concept Robots clearly defined?
Was concept Nursing clearly defined?
Was the content of the study clearly described?
Was selection of participants clearly reported?
Were sufficient cases included?
Was data collection appropriately reported?
Was the data analysis clearly reported?
Was sufficient data presented?
Were the credibility and confirmability clearly addressed?
Were the authors positions clearly stated?
Are the results transferable?
Was the population clearly identified?
Was the sampling method clearly reported?
Was the size of the sample clearly reported?
Was the instrument sufficiently described?
Was the instrument validity and reliability clearly stated?
Was the data collection appropriately reported?
Was the response rate reported?
Was the data analysis clearly reported?
Are results generalisable?

11. Synthesis

The findings of each paper will be scrutinised and compared and contrasted with each other to synthesise key messages about the following: the role and activities that robots can undertake, nurses' perceptions and attitudes to robots undertaking nursing activity and the disadvantages or barriers to robots in nursing.

Appendix 5. Presentation of Phase 1&2 Findings to Phase 3

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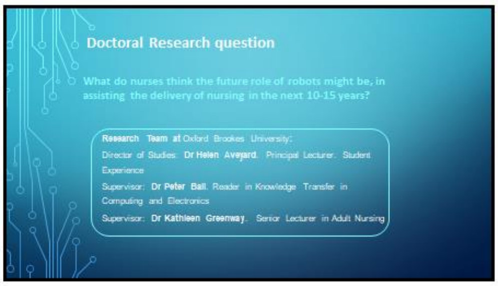

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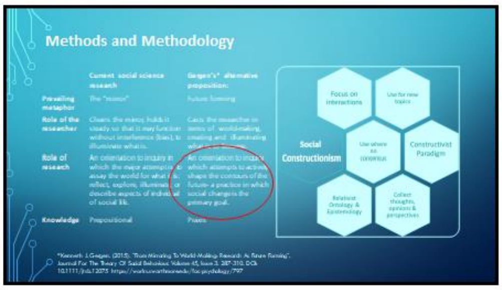

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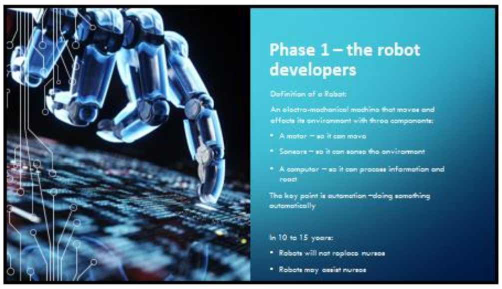

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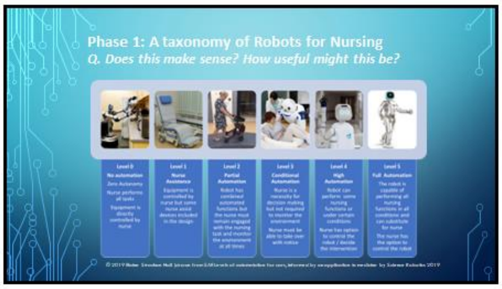

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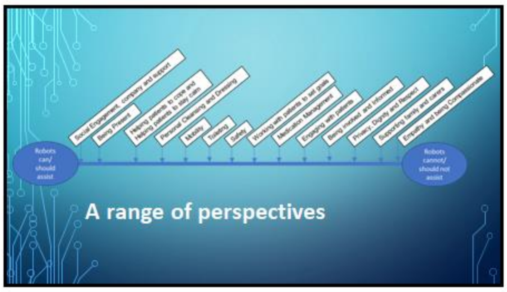

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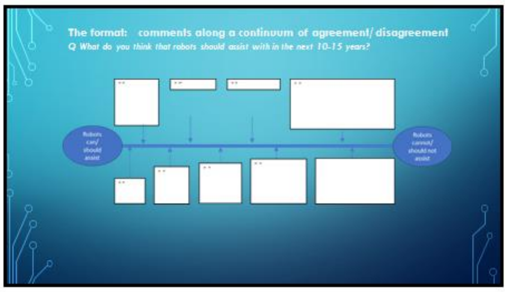

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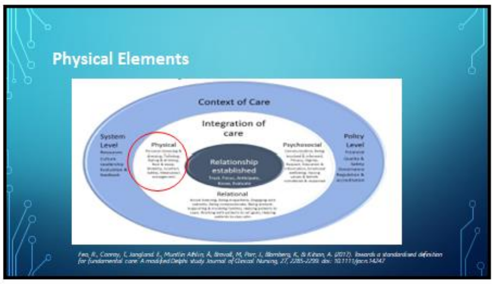

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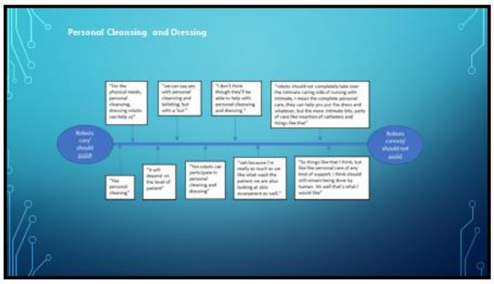

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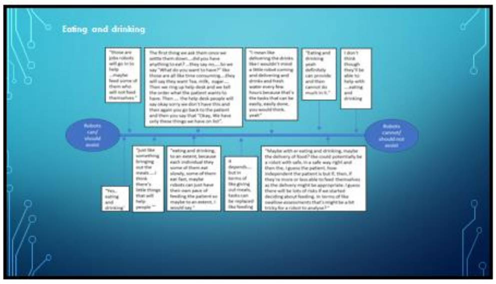

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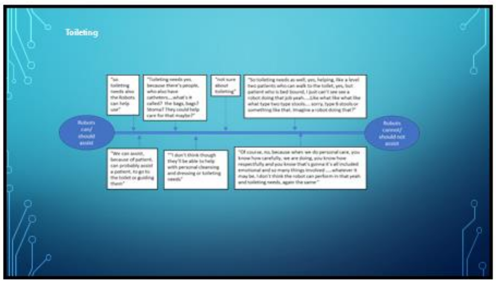

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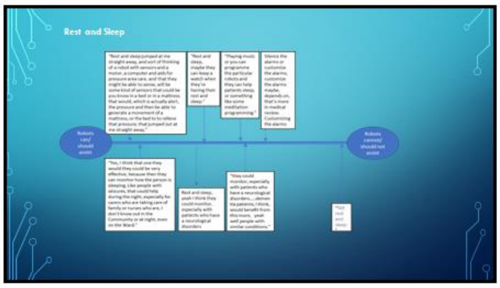

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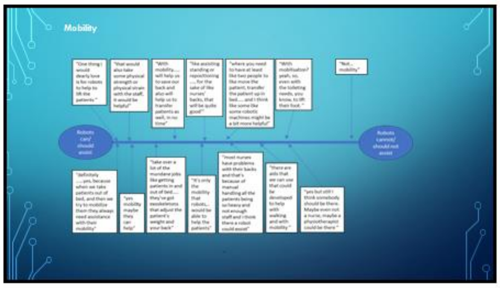

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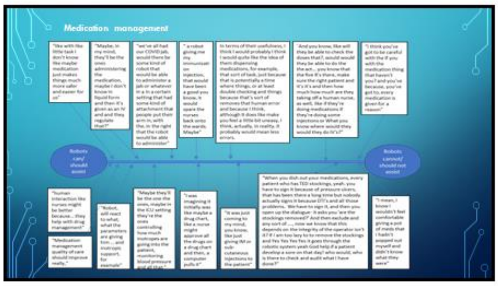

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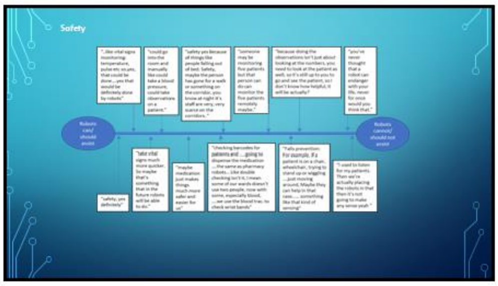

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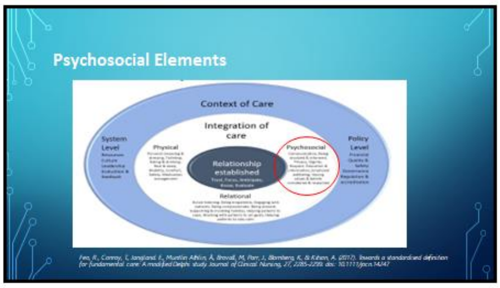

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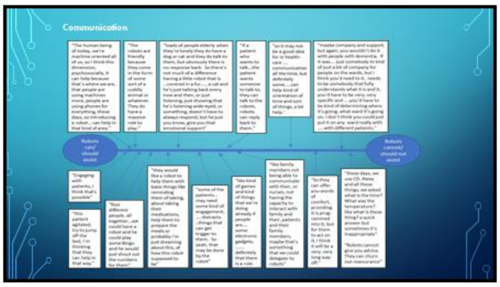

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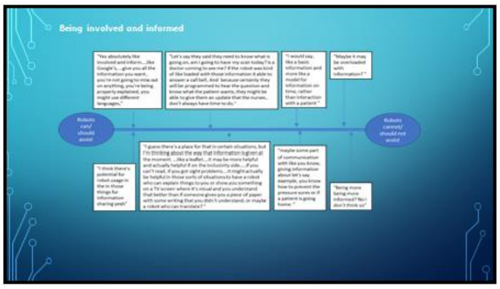

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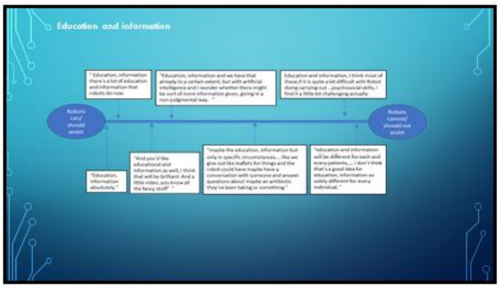

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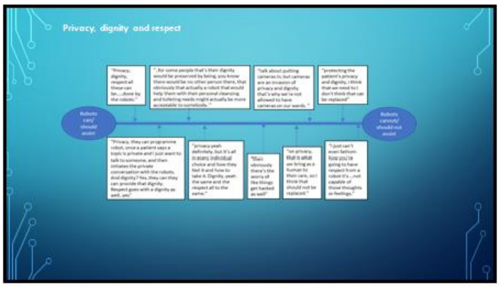

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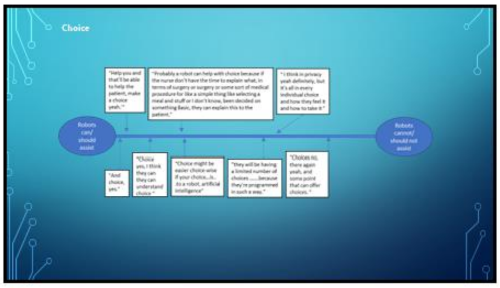

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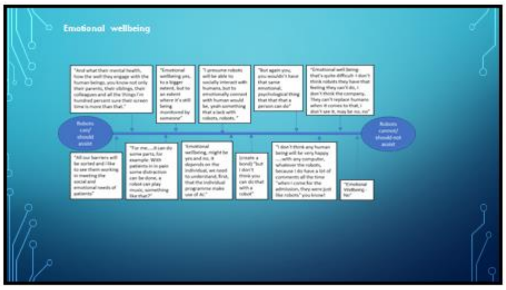

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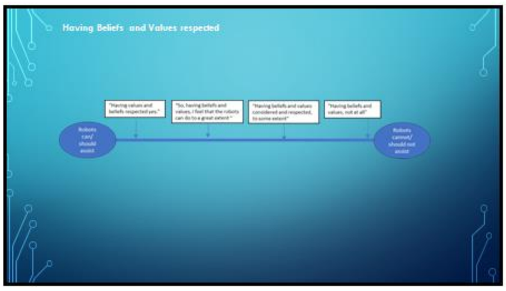

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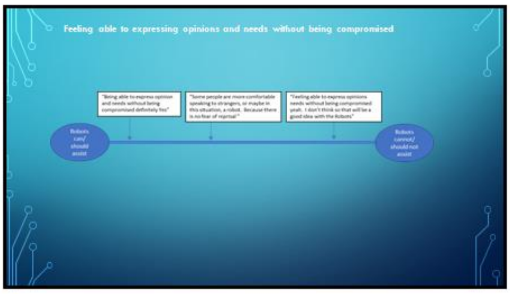

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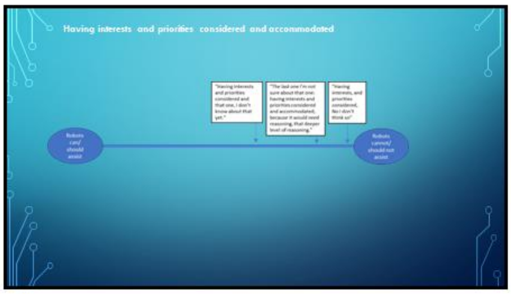

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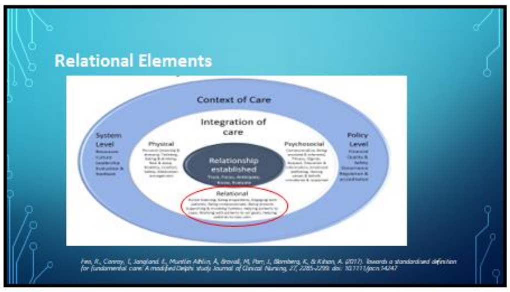
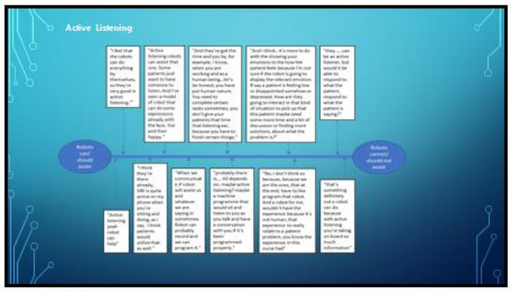

Relational Elements
Context of Care
Integration of care
System Level
Physical
Psychosocial
Policy Level
Relationship established
Relational

29


Active Listening
Robots can/ should assist
Robots cannot/ should not assist

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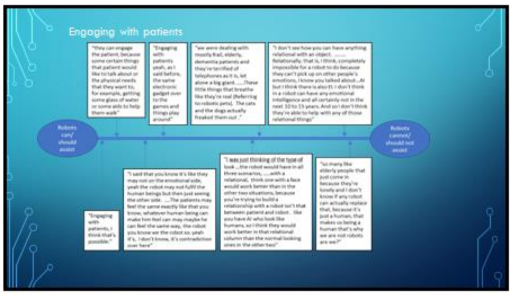
Engaging with patients
Robots can/ should assist
Robots cannot/ should not assist

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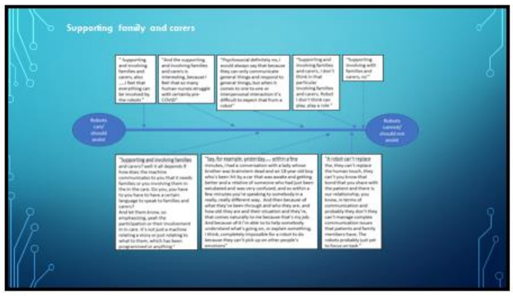
Supporting family and carers
Robots can/ should assist
Robots cannot/ should not assist

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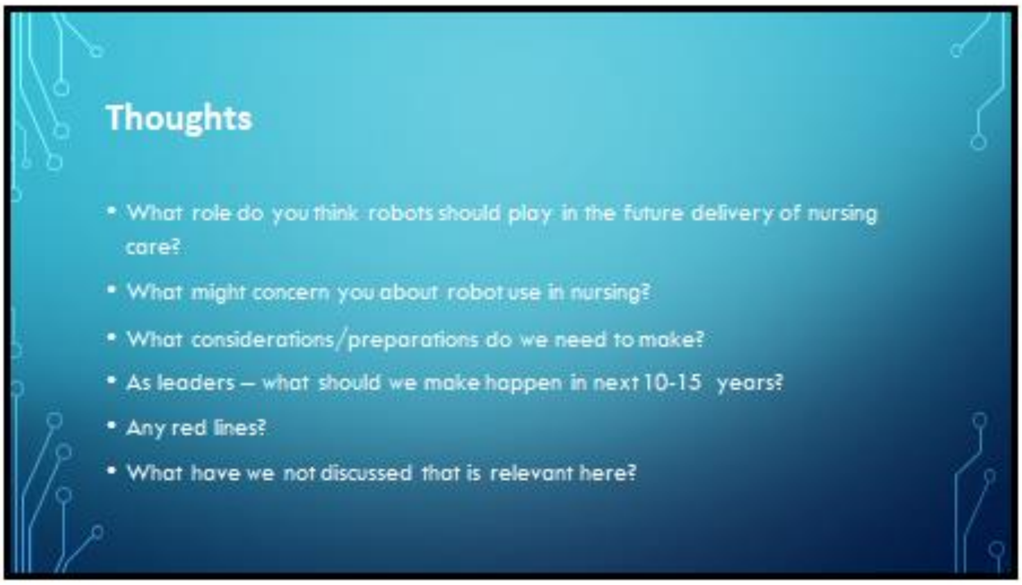
Thoughts
• What role do you think robots should play in the future delivery of nursing care?
• What might concern you about robot use in nursing?
• What considerations/preparations do we need to make?
• As leaders – what should we make happen in next 10-15 years?
• Any red lines?
• What have we not discussed that is relevant here?

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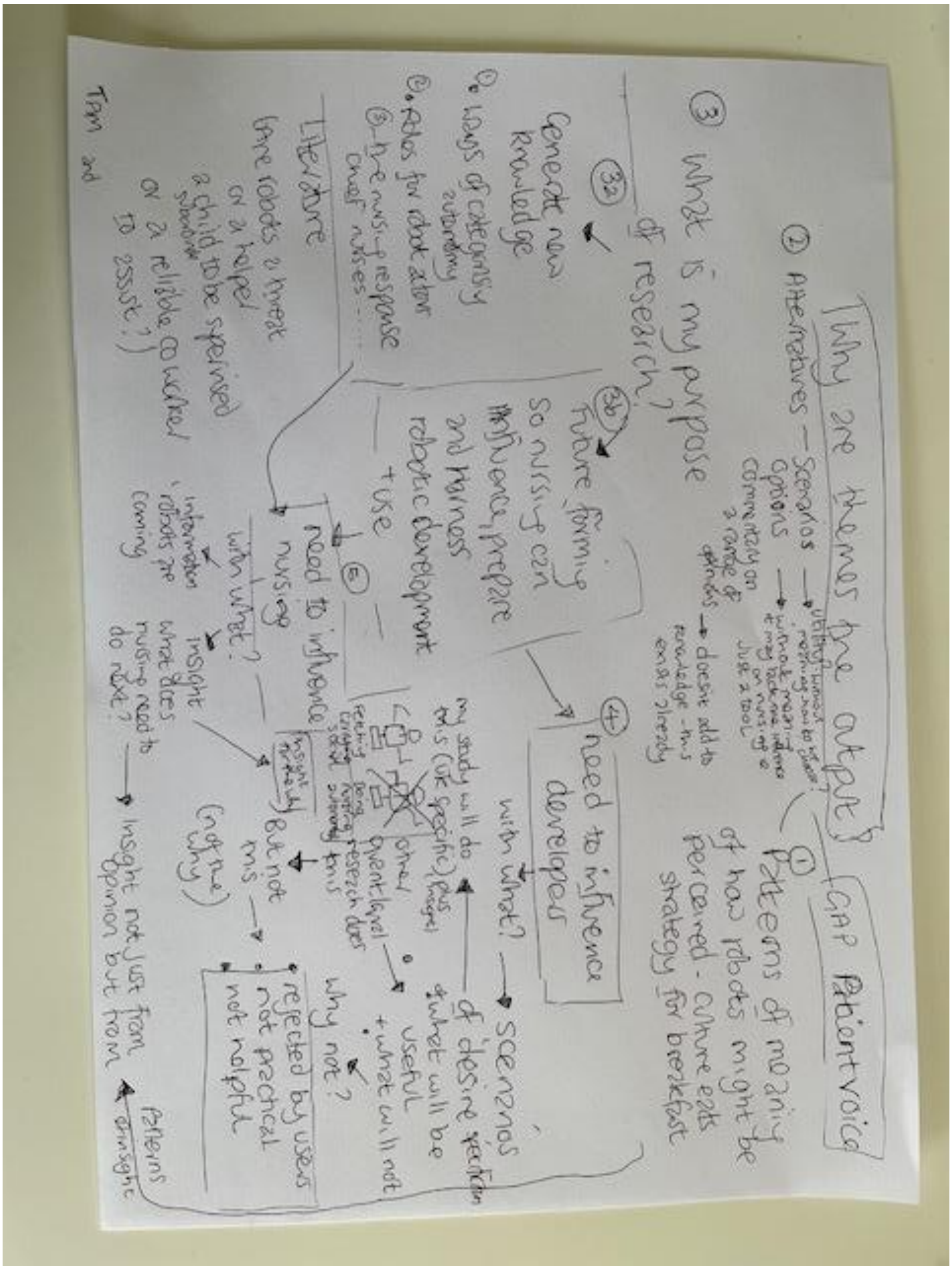
Appendix 6. Reflections on analysis- why themes are the output



Appendix 7. Participant Information Sheet

OXFORD BROOKES UNIVERSITY

IRAS Study Number 280071 FREC Study Number F.07.2019.35

Participant Information Sheet for Registered Nurses (including privacy notice)

Study title: Robots in Nursing

Invitation to participate

You are being invited to take part in a research study. Before you decide whether or not to take part, it is important for you to understand why the research is being done and what it will involve. Please take time to read the following information carefully.

What is the purpose of the study?

Technology is often cited as part of the solution to future workforce concerns and this study aims to explore what the future role of robots could, and should, be in the next 10-15 years. The study will invite Registered Nurses to discuss the topic in one of a number of focus groups. The study aims to be completed by end of 2022 (COVID restrictions permitting).

Why have I been invited to participate?

You are being invited to participate as part of a general invitation to Registered Nurses in your Trust. A maximum of eight nurses who are providing front line ward based care, will be invited to attend each online focus group. Focus groups will also be taking place with Registered Nurses in other Trusts to gain a variety of views and perspectives.

What will happen to me if I take part?

The method of data collection will be through focus groups: small groups of 6-8 participants will discuss key questions together over a 90-minute period. To take part in this research, the researcher will need to know your name and contact details in order to invite you to the focus group and ensure completion of the consent form. Only the researcher (Elaine Strachan-Hall) and her Director of Studies Professor Jane Appleton will have access to these contact details and will ensure that no-one else can see this contact information.

Due to COVID-19 social distancing restrictions the first phase of focus groups will be conducted through an online web based conference platform such as Zoom or MS Teams. As in a face to face focus group, participants will be able to see each other and discuss their reactions, perspectives, agree, disagree and share their thoughts with others. Conference platforms allow audio-visual recording and a chat function, and this will be utilised to record the focus group conversation. Participants will be encouraged to contribute with their camera on but will have the ability to contribute with camera off or to join by audio only.

The focus group recordings will be auto-transcribed with any 'chat notes' and notes of the interactions taken by the researcher. You should be aware that with audio-visual recording there is a risk that others may be captured on video if they are present in the background (3rd parties). Similarly if you use someone else's account to log in, this identifier (such as user name and images) may be visible to others. This could increase the risk of a data breach in terms of identification, therefore If possible, please use your own account to log in and feel free to make use of conference platform background selection which can eliminate background images.

After each focus group all audio-visual files will be immediately uploaded to a secure Google Drive for which the University has a Data Security agreement. Should any 3rd Party data be captured inadvertently -it will be deleted and will not be used or referred to in any way. Participants will also be able to recognise each other and therefore discussion will take place at the beginning of each focus group to agree non-attributability of contributions. The use of video recording could increase the risk of a data breach, although all video and audio-visual recordings will be deleted once transcription has been completed and checked for accuracy. ***Should you wish to take part in a face to face focus group rather than the online focus group described above-please refer to consent form b.***

Do I have to take part?

Participation is entirely voluntary, and it is up to you to decide whether or not to take part in this research study. If you do not choose to take part that is fine, and no further contact will be made with you. If you do decide to take part, you will be given this information sheet and be asked to give your consent in writing by returning a form provided by email. You can still stop being part of the study at any time and without giving a reason. Choosing to either take part or not in the study will have no impact on your appraisal or performance assessment and no impact on your current/future employment.

You are free to leave the focus group at any time, however we will keep any data collected prior to this. This is because removal can affect the coherence and integrity of the data and it is not always possible to identify who said what. The sections below details how data will be treated, and your anonymity protected.

What are the possible disadvantages and risks of taking part?

The main disadvantage to taking part is the time commitment for the 90-minute time period of participation, however the Chief Nurse has kindly agreed that this can be within work time. Albeit unlikely, it is possible that the topic area and discussion may elicit personal concerns for individual participants. Ongoing confidential support will be made available if required and will be sensitively managed within the group at the time. External support can be accessed at: https://www.rcn.org.uk/get-help/member-support-services/counselling-service. Or consider https://www.practitionerhealth.nhs.uk/covid-19-workforce-wellbeing.

What are the possible benefits of taking part?

The benefit of involvement is the opportunity to consider this topic and put forward your views and opinions which in turn may influence future nursing policy decisions. At a minimum, taking time to consider this topic will further understanding of the topic and provide opportunity for revalidation reflection (copies of NMC Revalidation Reflection paperwork will be available for participants to complete for their personal use).

Will what I say in this study be kept confidential?

Yes, we will keep all information about you safe and secure: all information collected will be kept strictly confidential (subject to legal limitations including the duty to act without delay if there is a risk to patient safety or public protection). Your name/ contact details may be used to make sure that the research is being done properly. This contact information will be kept separately from the research data (transcripts) and all raw data such as audio visual files will be kept securely in Google Drive. Sometimes commercially or professionally sensitive information may emerge in discussion. Any such information will be removed from transcripts and will not be published.

People who do not need to know who you are will not be able to see your name or contact details. In this research most of the research team will not need to know your name or where you work. Your name will be removed from the research data and replaced with a code and all transcripts will use a coding convention so participant names are not evident. This is called coded data or the technical term is pseudonymised data.

Anonymity will be ensured in the collection, storage and publication of research material. However, as a focus group consists of multiple participants, the duty of confidentiality (whilst strictly observed by the researcher) may not be observed by other participants. The topic is interesting and it is therefore natural that conversations may continue in weeks and months after the focus group, both between participants and with their friends and colleagues. This will be discussed at the beginning of each focus group and participants asked to commit to maintaining non-attributability of the discussion outside the focus group.

Laptops and other devices used for data collection or transfer will be password protected and any data files transferred electronically will be encrypted prior to transfer. Researchers must also make sure they manage research records in specific ways in order for the research to be reliable. This means you will be unable to see or change the data after it has been collected as research can go wrong if data is removed or changed.

Once the study is finished, some of the data will be kept in a pseudonymised form so results can be checked. Reports will be written in a way that no-one can work out who took part in the study. Participants will be asked for permission for an anonymised data set, gathered for this study, to be stored in a specialist data centre/ repository relevant to this subject area for future research. This will only happen if all participants in the focus group agree. Any future research will only use data that has been pseudonymised and will be held safely with strict limits on who can access it. This is referred to in the consent form. Your contact details will not be used to sell you anything and will not be given to other organisations.

Participant Information Sheet for RN v5.2 2/2/2021

This research will comply with the UK laws and rules including General Data Protection Regulations. Further information about what to do if you have concerns about the way your data is being handled are detailed below.

Data management

Oxford Brookes University (OBU) is the Data Controller of any data for this research. This means that we are responsible for looking after your information and using it properly. You can contact the University's Information Management Team on 01865 485420 or email info.sec@brookes.ac.uk.

OBU's legal basis for collecting this data is:

- You are consenting to providing it to us; and,
- Processing is necessary for the performance of a task in the public interest (research)

Why do we need your data?

This study aims to explore what the future role of robots might be in nursing. Your thoughts, views, reactions and opinions during a focus group discussion will form the data that this study will capture. This research aims to future debate on the subject of robots in nursing and to formulate recommendations on next steps for nursing.

The researcher will also ask you to complete a form recording your gender, the number of years of post-registration experience that you have and your ethnic background. This data is de-identified (it is not linked to your name) and **you do not have to give this data**. If you do give this data, it will be used in two ways – firstly it will be used collectively to describe the gender mix, ethnic backgrounds and total years of experience in each focus group in order to report on how similar or dissimilar each focus group is from each other. Secondly this information may be used to analyse specific findings by gender identity, experience and ethnic background. For instance, it may be that participants from different a country with more advanced technology may have a distinctly different viewpoint that is important to report.

What type of data will Oxford Brookes University use?

Data will include audio/video recordings, focus group transcripts, notes of observations and demographic data (years of experience, work role, gender identity and ethnicity). The online conferencing audio-video recording and auto-transcription will be utilised in this study with a second audio recording facility as back up. Notes may also be taken (by the researcher) of observations and this interaction data will also be noted because it gives a richer picture of the discussion.

Who will OBU share your data with?

The online web-based conferencing facility for auto-transcribe of content will be used. The data will primarily be accessed by the researcher (Elaine Strachan-Hall), although may be shared within the supervisory team for cross checking purposes. Data files will be created by the hosting platform for the online recording (ie Zoom or Microsoft Teams, and NVivo version 12 will also be used for data analysis and data sharing). Auto-transcription files will be checked against the recording for completeness and accuracy then de-identified. All video and audio recordings will then be deleted. All video and audio files will be deleted not later than 3 months after completion of the study.

Will OBU transfer my data outside of the UK? No data will be transferred outside the UK.

What rights do I have regarding my data that OBU holds?

- You have the right to be informed about what data will be collected and how this will be used
- You have a minimal right of access to your data (you have the right to access that data that can be clearly identified as your contributions or your data)
- You have minimal right to correct data if it is wrong
- You have a minimal right to ask for your data to be deleted but it is not possible to withdraw data after it has been recorded, this is because it will affect the coherence and integrity of the data and it not always possible to identify who said what.
- You have a minimal right to restrict use of the data we hold about you but this is limited to restricting the use of quotes that are clearly made by you if you do not wish to be reported as quotes (all quotes will be quoted anonymously)
- You have the right to data portability but this is limited as it is not possible to extract your data completely.
- You have the right to object to the university using your data
- You have rights in relation to using your data in automated decision making and profiling.

Where will OBU source my data from?

The only data that will be used is that provided by you as an interested potential participant (ie your contact details) and that data that is given by you in the focus group with your permission.

Are there any consequences of not providing the requested data?

There are no consequences of not providing data for this research. Taking part is purely voluntary.

Will there be any automated decision making using my data?

There will be no use of automated decision making in scope of UK Data Protection and Privacy legislation.

How long will OBU keep my data?

Data generated by the study will be retained in accordance with the University's policy on Academic Integrity. Pseudonymised data generated in the course of the research will be kept securely in paper or electronic form for a period of ten years after the completion of a research project so that it can be checked if necessary. Audio-visual recordings will be deleted once analysis is complete. However contact details and other identifiable information will be kept securely and destroyed after 3 months.

What will happen to the results of the research study?

These focus groups from part of the research of a professional doctorate in nursing and therefore will be used as part of a thesis. In addition, it is expected that the results of this research will be published and will form the content for conference papers and presentations. A summary of the results will be offered to each participant.

Who is organising and funding the research?

The researcher is a self funding doctoral student of Oxford Brookes University.

Who has reviewed the study?

Approval has been given by the Faculty Research Ethics Committee, and the Health Research Authority (HRA).

What should I do if I want to take part?

If you would like to take part, please read the consent form and complete either consent form A for the online focus group or B for the face to face group at a later date. Reply to the researcher Elaine Strachan-Hall by email (elaine-strachan-hall-2017@brookes.ac.uk) or text your contact details to 07(Study Specific SIM) with the text 'opt in robots' by (Insert date). Elaine Strachan-Hall will then contact you directly and explain the next steps.

Contact for Further Information

Please contact Elaine on **elaine-strachan-hall-2017@brookes.ac.uk** or 07(Study Specific SIM Number) or the Director of Studies Professor Jane Appleton at jvappleton@brookes.ac.uk for further information.

Who can I contact if I have concerns?

In the event of any questions about the research study, please contact the researchers in the first instance. If you have any concerns about the way in which the study has been conducted, you can contact the Chair of the Faculty of Health and Life Sciences Research Ethics Committee on frec@brookes.ac.uk.

For further details about information security contact the Data Protection Officer: brookesdpo@brookes.ac.uk or should you be concerned about the way your data is being used you can also contact the University data protection officer on info.sec@brookes.ac.uk. If you are not happy with the response or believe that your data is being processed in a way that is not right or lawful, you can also complain to the Information Commissioners Office (ICO) www.ici.org.uk or 0303 123 1113.

Given that this is health research you can also refer to the information on the HRA website: https://www.hra.nhs.uk/planning-and-improving-research/policies-standards-legislation/data-protection-and-information-governance/gdpr-guidance/templates/transparency-wording-nhs-organisations/

Thank you for taking time to read the information sheet and for your interest in this topic.

Elaine Strachan-Hall RGN, MSc, MBA, HonDUniver. Professional Doctorate in Nursing Student Brookes University. **E: elaine-strachan-hall-2017@brookes.ac.uk. M: 07752075783 (Study Specific SIM)**
Research Team at Oxford Brookes University**:**
Director of Studies: **Jane Appleton**. Professor of Primary and Community Care,
Supervisor: **Dr Peter Ball**. Reader in Knowledge Transfer in Computing and Electronics
Supervisor: **Dr Kathleen Greenway**. Senior Lecturer in Adult Nursing

Appendix 8. Consent form

IRAS Study Number 280071
FREC No F.07.2019.35

OXFORD BROOKES UNIVERSITY

CONSENT FORM: The role of Robots in Nursing
For Registered Nurses and Chief Nurses

Elaine Strachan-Hall, Professional Doctorate in Nursing Student at Oxford Brookes University. Contact elaine.strachan-hall-2017@brookes.ac.uk.

	Please initial box
1. I confirm that I have read and understand the information sheet for the above study and have had the opportunity to ask questions.	☐
2. I understand that my participation is voluntary and that I am free to withdraw at any time, without giving reason.	☐
3. I understand that due to the nature of focus group discussion, it may not be possible to extract my contributions to the discussions – therefore data cannot be withdrawn.	☐
4. I agree to take part in the above study.	☐
5. I understand that the Focus Group will be audio-visually recorded and I can contribute with camera on or camera off facility	☐

	Please initial box Yes	No
6. I agree to my contributions being video recorded	☐	☐
7. I agree to the use of anonymised quotes in publications	☐	☐
8. I agree that an anonymised data set, gathered for this study may be stored in a specialist data centre/repository relevant to this subject area for future research	☐	☐

Name of Participant ____________ Date ____________ Signature ____________

Name of Researcher ____________ Date ____________ Signature ____________

RN & CN Consent Form v3.0. 01/08/2020

Appendix 9. University and HRA Approvals

Ymchwil Iechyd a Gofal Cymru
Health and Care Research Wales

NHS
Health Research Authority

Professor Jane Appleton
Oxford Brookes University
Jack Straws Lane,
Marston,
Oxford
OX3 0FL

Email: approvals@hra.nhs.uk
HCRW.approvals@wales.nhs.uk

11 February 2021

Dear Professor Appleton

HRA and Health and Care Research Wales (HCRW) Approval Letter

Study title:	**What do nurses think the future role of robots should be in the delivery of therapeutic nursing care in the next 10-15 years?**
IRAS project ID:	**280071**
Protocol number:	**F.07.2019.35**
REC reference:	**20/HRA/6062**
Sponsor	**Oxford Brookes University**

I am pleased to confirm that **HRA and Health and Care Research Wales (HCRW) Approval** has been given for the above referenced study, on the basis described in the application form, protocol, supporting documentation and any clarifications received. You should not expect to receive anything further relating to this application.

Please now work with participating NHS organisations to confirm capacity and capability, in line with the instructions provided in the "Information to support study set up" section towards the end of this letter.

How should I work with participating NHS/HSC organisations in Northern Ireland and Scotland?
HRA and HCRW Approval does not apply to NHS/HSC organisations within Northern Ireland and Scotland.

If you indicated in your IRAS form that you do have participating organisations in either of these devolved administrations, the final document set and the study wide governance report (including this letter) have been sent to the coordinating centre of each participating nation. The relevant national coordinating function/s will contact you as appropriate.

Please see IRAS Help for information on working with NHS/HSC organisations in Northern Ireland and Scotland.

How should I work with participating non-NHS organisations?
HRA and HCRW Approval does not apply to non-NHS organisations. You should work with your non-NHS organisations to obtain local agreement in accordance with their procedures.

What are my notification responsibilities during the study?

The *"After HRA Approval – guidance for sponsors and investigators"* document on the HRA website gives detailed guidance on reporting expectations for studies with HRA and HCRW Approval, including:

- Registration of Research
- Notifying amendments
- Notifying the end of the study

The HRA website also provides guidance on these topics and is updated in the light of changes in reporting expectations or procedures.

Who should I contact for further information?
Please do not hesitate to contact me for assistance with this application. My contact details are below.

Your IRAS project ID is **280071**. Please quote this on all correspondence.

Yours sincerely,
Kathryn Davies

Approvals Specialist

Email: approvals@hra.nhs.uk

Copy to: *Ms Kellie Tune*

List of Documents

The final document set assessed and approved by HRA and HCRW Approval is listed below.

Document	*Version*	*Date*
Copies of materials calling attention of potential participants to the research [Poster to invite RN]	v3.1	21 June 2020
Copies of materials calling attention of potential participants to the research [Sample text for RN Recruitment]	v1.2	20 December 2020
Copies of materials calling attention of potential participants to the research [Sample Text for CN Recruitment]	v1.2	20 December 2020
Evidence of Sponsor insurance or indemnity (non NHS Sponsors only) [Insurance Confirmation]		
Interview schedules or topic guides for participants [RN Topic Schedule]	v2.0	20 June 2020
Interview schedules or topic guides for participants [CN Topic schedule]	v3.0	21 June 2020
IRAS Application Form [IRAS_Form_04122020]		04 December 2020
Letter from sponsor [Sponsor Letter]		24 September 2020
Letters of invitation to participant [RN Invite letter]	v2.1	01 August 2020
Letters of invitation to participant [CN Invite letter]	v2,2	01 August 2020
Letters of invitation to participant [Phase 4 RN invitation letter]	v2.2	01 August 2020
Non-validated questionnaire [Personal Data Collection Form]	v2.0	01 August 2020
Organisation Information Document [Blank OID]	1-6	04 February 2021
Other [Introductory Chief Nurse email]	v3.1	01 August 2020
Other [Revalidation reflection form]	v1.0	21 June 2020
Other [Letter to CNO re CN recruitment]	v2.1	01 August 2020
Other [Email to CN inviting participation]	v2.3	01 August 2020
Other [Reminder text for nurse participants]	v1.0	21 June 2020
Other [Additional Comments proforma]	v1.3	01 August 2020
Other [Trustworthiness Protocol]	v1.1	01 August 2020
Other [Governance Template]		29 September 2020
Other [Cover letter to RN]	v2.4	19 December 2020
Other [Additional Comments proforma]	v1.3	01 August 2020
Other [Supervisors CV document]	2020	16 December 2020
Other [Supervisors CV document]	2020	16 January 2021
Participant consent form [RN /CN Consent Form]	v3.0	01 August 2020
Participant consent form [Phase 4 RN Consent Form]	v3.3	01 August 2020
Participant information sheet (PIS) [RN Participant information Sheet]	v5.2	02 February 2021
Participant information sheet (PIS) [CN Participant Information Sheet]	v5.2	02 February 2021
Participant information sheet (PIS) [Phase 4 RN Participant Information Sheet]	v3.2	02 February 2021
Research protocol or project proposal [Qualitative Protocol]	4.7	27 November 2020
Schedule of Events or SoECAT [Schedule of Events UCLH]	1.1	30 October 2020
Schedule of Events or SoECAT [Schedule of Events Epsom]	1.1	17 October 2020
Schedule of Events or SoECAT [schedule of Events Barts]	1.1	17 October 2020
Schedule of Events or SoECAT [Schedule of Events MKFT]	1.1	17 October 2020

Summary CV for Chief Investigator (CI) [CV document]	V1.0	05 October 2020
Summary CV for supervisor (student research) [CV document]		
Summary, synopsis or diagram (flowchart) of protocol in non technical language [Study Design Schematic]	v2	30 October 2020

IRAS project ID	280071

Information to support study set up

The below provides all parties with information to support the arranging and confirming of capacity and capability with participating NHS organisations in England and Wales. This is intended to be an accurate reflection of the study at the time of issue of this letter.

Types of participating NHS organisation	Expectations related to confirmation of capacity and capability	Agreement to be used	Funding arrangements	Oversight expectations	HR Good Practice Resource Pack expectations
All sites will perform the same research activities therefore there is only one site type.	Research activities should not commence at participating NHS organisations in England or Wales prior to their formal confirmation of capacity and capability to deliver the study.	An Organisation Information Document has been submitted and the sponsor is not requesting and does not expect any other site agreement to be used.	No study funding will be provided to sites as per the Organisational Information Document	A Local Collaborator should be appointed at study sites	No Honorary Research Contracts, Letters of Access or pre-engagement checks are expected for local staff employed by the participating NHS organisations. Where arrangements are not already in place, research staff not employed by the NHS host organisation undertaking any of the research activities listed in the research application would be expected to hold Letters of Access if focus groups/interviews were held in clinical areas. Letters of Access would not be expected if they were held in non-clinical/administrative buildings.

Other information to aid study set-up and delivery

This details any other information that may be helpful to sponsors and participating NHS organisations in England and Wales in study set-up.
The applicant has indicated that they do not intend to apply for inclusion on the NIHR CRN Portfolio.

Oxford Brookes University

Faculty of Health and Life Sciences

Decision on application for ethics approval

The Departmental Research Ethics Officer (DREO) / Faculty Research Ethics Committee (FREC) has considered the application for ethics approval for the following project:

Project Title: What do nurses think the future role of robots should be in the delivery of therapeutic nursing care in the next 10-15 years?

FREC Study Number: F.07.2019.35

Name of Applicant: Elaine Strachan-Hall

Please tick one box

1. The Faculty Research Ethics Committee gives ethical approval for the research project. √ ☐

   Please note that the research protocol as laid down in the application and hereby approved must not be changed without the approval of the DREO / FREC

2. The Departmental Research Ethics Officer / Faculty Research Ethics Committee gives ethical approval for the research project, subject to the following: ☐

3. The Departmental Research Officer / Faculty Research Ethics Committee cannot give ethical approval for the research project. The reasons for this and the action required are as follows: ☐

Signed: …Kellie Tune … ……………………… Approval Date:.22 September 2020………

Designation: Departmental Research Ethics Officer

(Signed on behalf of the Faculty Research Ethics Committee)

Date when application reviewed (*office use only*): 7 July 2020…………………..

H&LS/FRec/E3 August 2011

Elaine Strachan-Hall
Oxford Brookes University
Marston Road Campus
Jack Straws Lane
OX3 0FL

22 September 2020

Dear Elaine,

Re. What do nurses think the future role of robots should be in the delivery of therapeutic nursing care in the next 10-15 years?

Thank you for submitting your response to FREC on the 17 September 2020. I can confirm that you have addressed the points of clarification and amendment. I am pleased to approve the research by Chair's Action. I wish you all the with the study. You may now proceed with the recruitment of roboticists and the pilot for your interviews. However you will need to have HRA approval before proceeding with any NHS recruitment. You may now submit to HRA and liaise with R&D.

Yours sincerely

Kellie Tune
Chair, Faculty of Health and Life Sciences Research Ethics Committee

Cc –Ruzena Zemanova

Appendix 10. Trustworthiness Protocol

Trustworthiness Protocol		
Big Tent Criterion	Key Criteria	Proposed Actions
Worthy Topic	Relevant Timely Significant Interesting	Describe relevance in terms of workforce challenge Describe timeframe of 15 years in terms of foreseeability v conjecture. Provide literature on significance to nursing Indicate interest in terms of media coverage / nursing press interest
Rich Rigor	Theoretical Constructs Data and time in the field Sample Context Data collection and analysis	Social Constructionist approach consistent with constructionist paradigm, subjective, relativist approach Richness generated by capture of language and non-verbal observations within focus groups using field notes and audio recording. Set up and conduct will be described. (Cross-check review by peer or supervisor) 4-6 focus groups are planned for Registered Nurses and 2-3 of Chief Nurses Analysis using inductive thematic analysis will report consistency of researcher intervention in each group plus this will be reported in final report
Sincerity Including Confirmability	Reflexivity Transparency about methods and challenges	Use of reflective journal including all supervision Clear presentation of researcher perspective prior to and throughout study. Presentation of key decisions and rationale in final write up Transparency on rationale of decision making Thread reflections through report using first person voice and clearly differentiated in the report Check out pitfalls ie catharsis or squeezing out object of study with supervisors
Credibility	Thick description Triangulation /crystalisation Multi-vocality Member reflections	Advise in advance that post reflections are welcome on the process Use thick descriptions and record participation data including non-verbal cues and interactions Employ emersion from transcription and practice presenting and discussing with peers and re-listening to actual audio with transcription multiple times

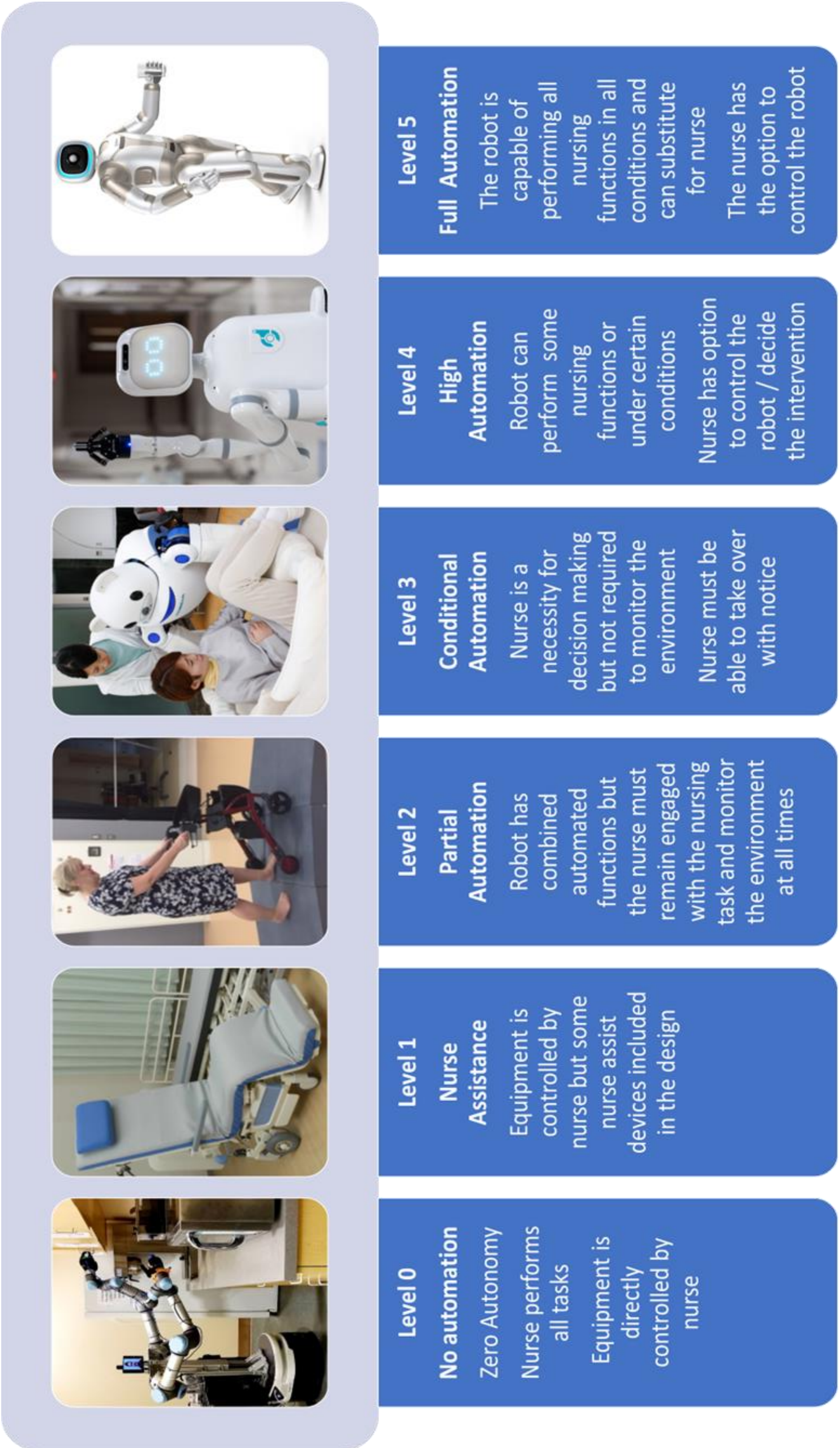
		Triangulation and crystallisation are not appropriate to data and therefore multivocality will be of pivotal importance. This will need careful moderation to ensure all voices are heard and reported Member reflections in the form of inviting further reflections on transcription will be considered further and tested for the practice group for practicality and impact
Resonance	Aesthetic, evocative representation Naturalistic generalisations Transferable findings	Consideration of how reports are presented – perhaps pictorially or through film. (the pre-study activity for the Churchill fellowship plans to use film and vox box-type recordings to illustrate robot capability). This could provide background to the study presentations. Thought of different nursing contexts will be considered throughout the analysis
Significant Contribution	Provides a contribution: conceptually and theoretically Practically Morally Methodologically Heuristically	The study expects to be one of few on this topic area in the UK and probably the only one which will combine the views of front line nurses and chief nurses in order to inform future debate and planning. It is planned that the study will be able to postulate what nurses think is acceptable for robots in assisting the delivery of therapeutic nursing care and the impact on nursing that introduction of robots may make (positively or negatively) In addition insight into possible barriers and enablers will allow nurses in a strategic planning context to be more informed about future policy decisions and future research.
Ethical	Procedural ethics Situational and cultural ethics Relational ethics Exiting ethics (leaving the scene and sharing results	The procedural process of protecting participants is presented in the protocol and IRAS form. The study will consider the ethical dimensions of robots in nursing care which potentially will touch on ethical frameworks about what it is to be human and what are the ethical dimensions of non-human caring and particularly machine learning. Exiting ethics is particularly important as this topic area is immensely contentious and will be seen by some as undermining nursing which in turn could harm recruitment and retention. Responsible and not salacious reporting will therefore be critical

Meaningful coherence	Achieves what it purports to be about Uses methods and procedures that fit goals Meaningfully connects literature, findings and interpretations	Detailed and accessible review of the literature in order to raise understanding of potentials over the next year Considering analysis methods and member reflections because they are methodologically coherent Choice of Social constructionism because of its coherence with project aims.

Appendix 12: Example of full text from Roboticist Framework Analysis

Roboticist Definitions of a robot		
	Full text definition of a robot	**Summary definition**
Roboticist 1	"So I actually when I give presentations to non-technical people I use the washing machine photo as an example of the metaphor of a robot. Because the washing machine is a robot, is a machine which can sense the environment and act on it to produce some, some behavior. So washing machine senses the weight of the load, senses the temperature and then decides to speed or not. to be. So Robot, is a continuum of course, typically, when we refer to robots we imagine some kind of mobile Robot on wheels some kind of humanoid robot with Legs and arms or I agree wheelbase, the moving element with some arms to pick up objects. So this is what we really typically refer to".	'A machine which can sense the environment and act on it to produce some behaviour'
Roboticist 2	"Okay so well for what I say to students, when I, when I teach is that the robot, it's, it's a, it's a, an electromechanical system that moves. So I put attention on the fact that it should move, just to make the two separate between Robots and Artificial intelligence in general, especially because recently we are hearing a lot about AI and artificial intelligences and sometimes these are just, I will say "just" computer programs. (hand gesture of speech marks) which is different from a robot. So so Robot, it's a electromechanical system in typically that can move and it's programmed by your by your computer. (Yeah), so I will say that's the classic definition. So typically, then Robot is composed by motors and sensors, motors to move and sensors to perceive the, something in the environment. Although, there might be simple, Let's say simpler robots that do not have almost any sensors and they will just move but if it's only sensors and without motors, without movement that then is definitely not a robot"	'An electromechanical system that moves, programmed by your computer, composed of motors to move and sensors to perceive something in the environment'
Roboticist 3	"My definition, of a robot is a machine that the senses input and then reacts in in a certain in a certain fashion. We can either be mechanistic or it could be intellectual. Yeah. So that would cover also robots that don't have perception, but they just react to open to inputs from a human, but also react to robots that just have cameras and move around. So I think Robots are a machine that can sense its environment, or a limited aspect of its environment and then react to it, either by action or by talk something. Yes, it [movement] used to be very important, it used to be that the robot should have moving components. But increasingly, we see that, you know, people talk about. Yeah, and I mean I think otherwise it doesn't have some sort of action on the environment. Yeah, it's probably limited to being an algorithm. So some sort of interaction with the environment is required"	'Robots are a machine that can sense its environment, or a limited aspect of its environment and then react to it, either by action or by talk something, some sort of interaction with the environment is required'
Roboticist 4	I think my definition of a robot would be some device that performs kind of a relatively well-defined task within certain parameters and as a result, it could either be kind of hardware based. Perhaps the for instance like a lunar rover, etc. That kind of robot or software-based, for instance, like a voice assistant, so something that anything is operating within kind of a fixed range of parameters. I think my definition coming into this would be quite general to say that device doesn't have any constraints on how it's, whether it's hardware or software or even biological, if it's possible to imagine a biological robot in some sense, I guess in some sense.	'A device that performs a relatively well-defined task within certain parameters, it may be hardware or software or even biologically based'
Roboticist 5	Well it's like a spectrum, you know. It has to perceive its environment, it's some kind of machine which can perceive its environment and make decisions based on its perceptions to actually do things in the real world and those things for me they could be physical things like, you know, picking something up and putting it somewhere. But we're moving, but I also care about doing speech actions. I think by talking, you're also affecting the real world. I mean, even a washing machine is a kind of robot that washes clothes. For me, I'm more interested in automation, different levels of automation really So I think you know, and then there's the issue. There's the issue of autonomy, so I guess you know whether, to what extent the machine is making some sort of decision on its own. So I guess a washing machine, you know, is not really making any decisions on its own, unless it maybe has a sensor about water temperature getting too high, and then it switches itself off. Then you then you're moving slightly towards a more autonomous machine. So yeah, I mean, the main things are sensing, sensing environment, making some sort of decisions autonomously, those decisions could be movement or the things that I care about are talking really	'It's a spectrum of machines which can perceive its environment and make decisions based on its perceptions to do things in the real world (physical things or speech actions), sensing environment and making some sort of decisions autonomously'

Appendix 13: Taxonomy



Appendix 13. The Fundamentals of Care Framework

13.1. Physical dimension of FOC Framework

Figure 13.1.1. RN quotes on Rest and Sleep

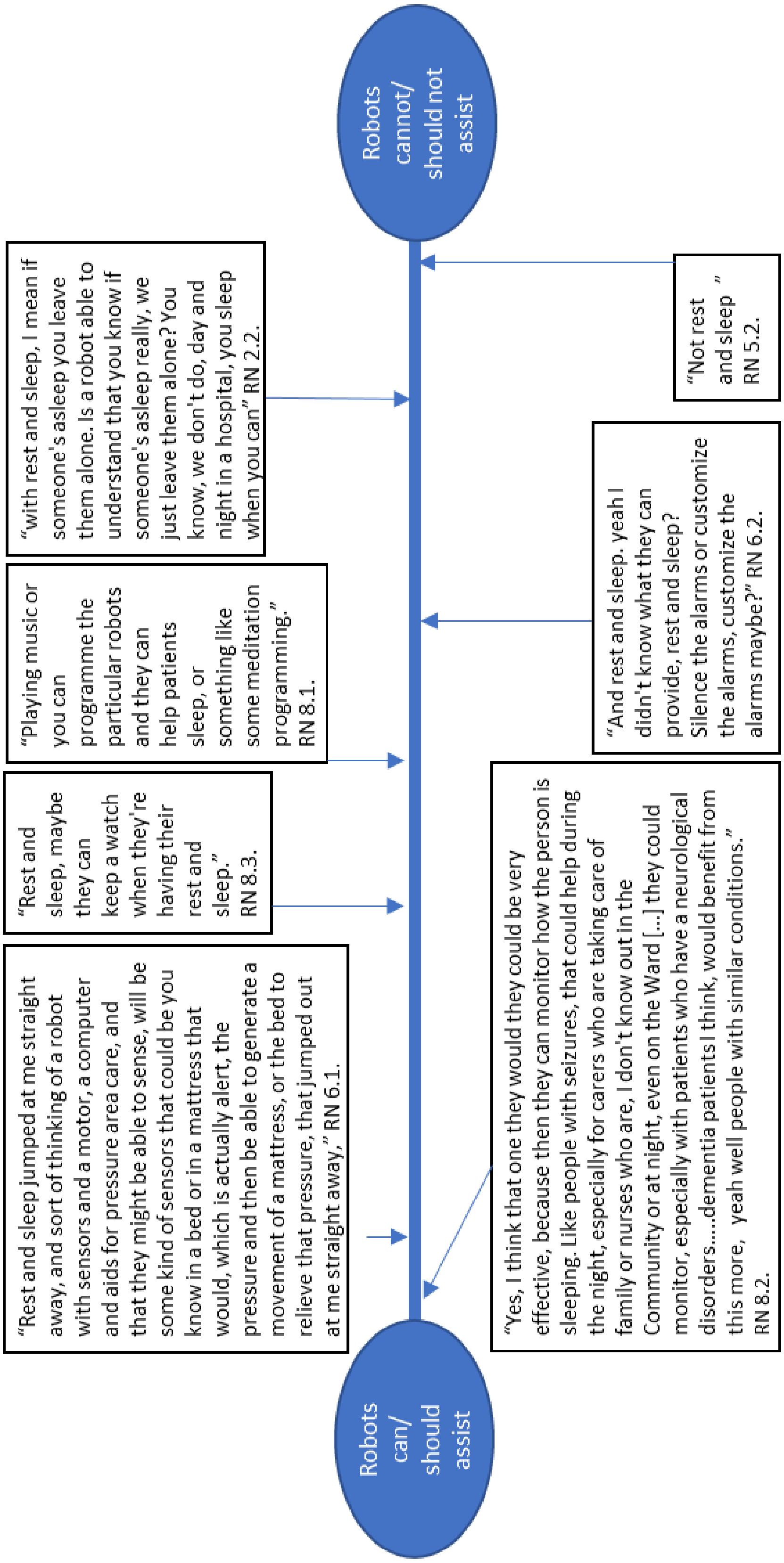


Figure 13.1.2. RN quotes on Personal Cleansing and Dressing

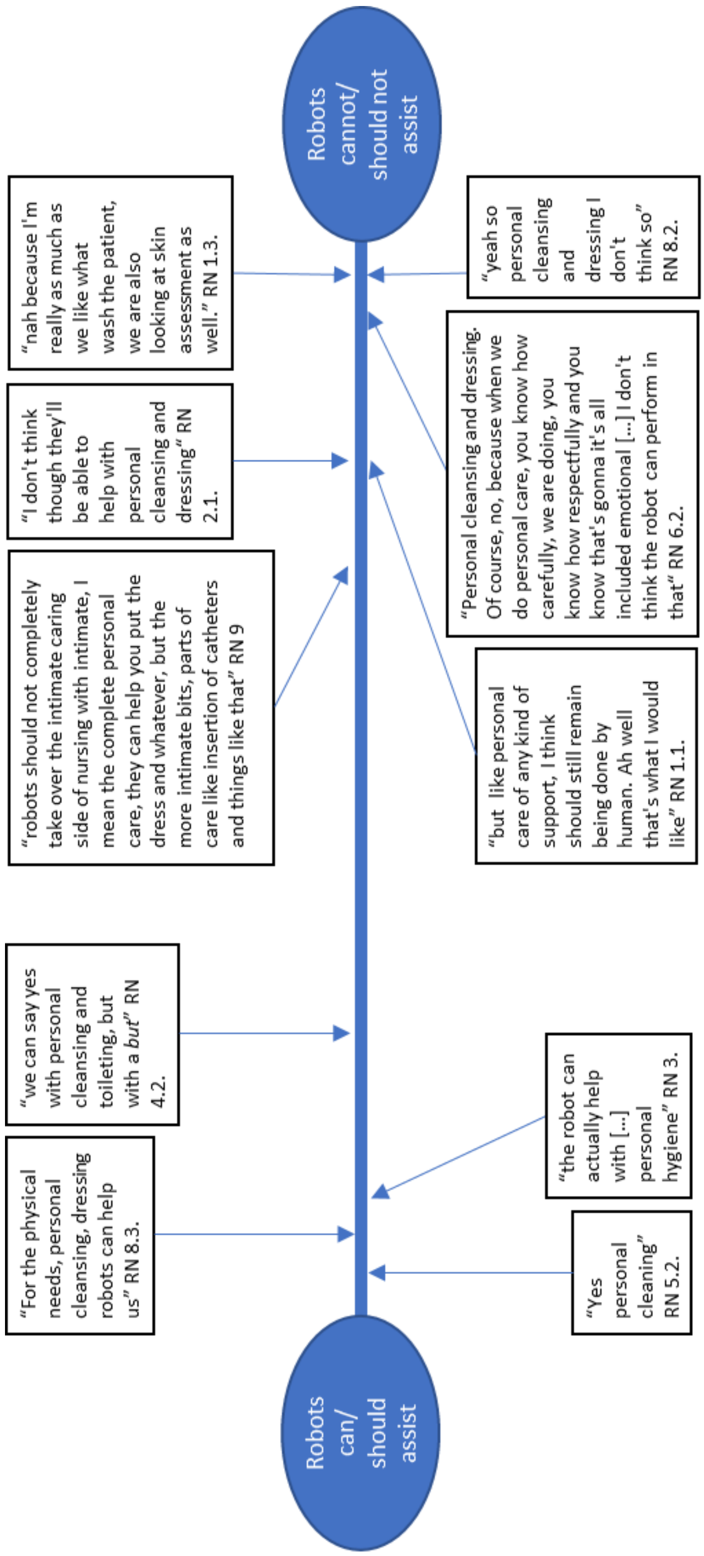


Figure 13.1.3. RN quotes on robots assisting with Medication Management

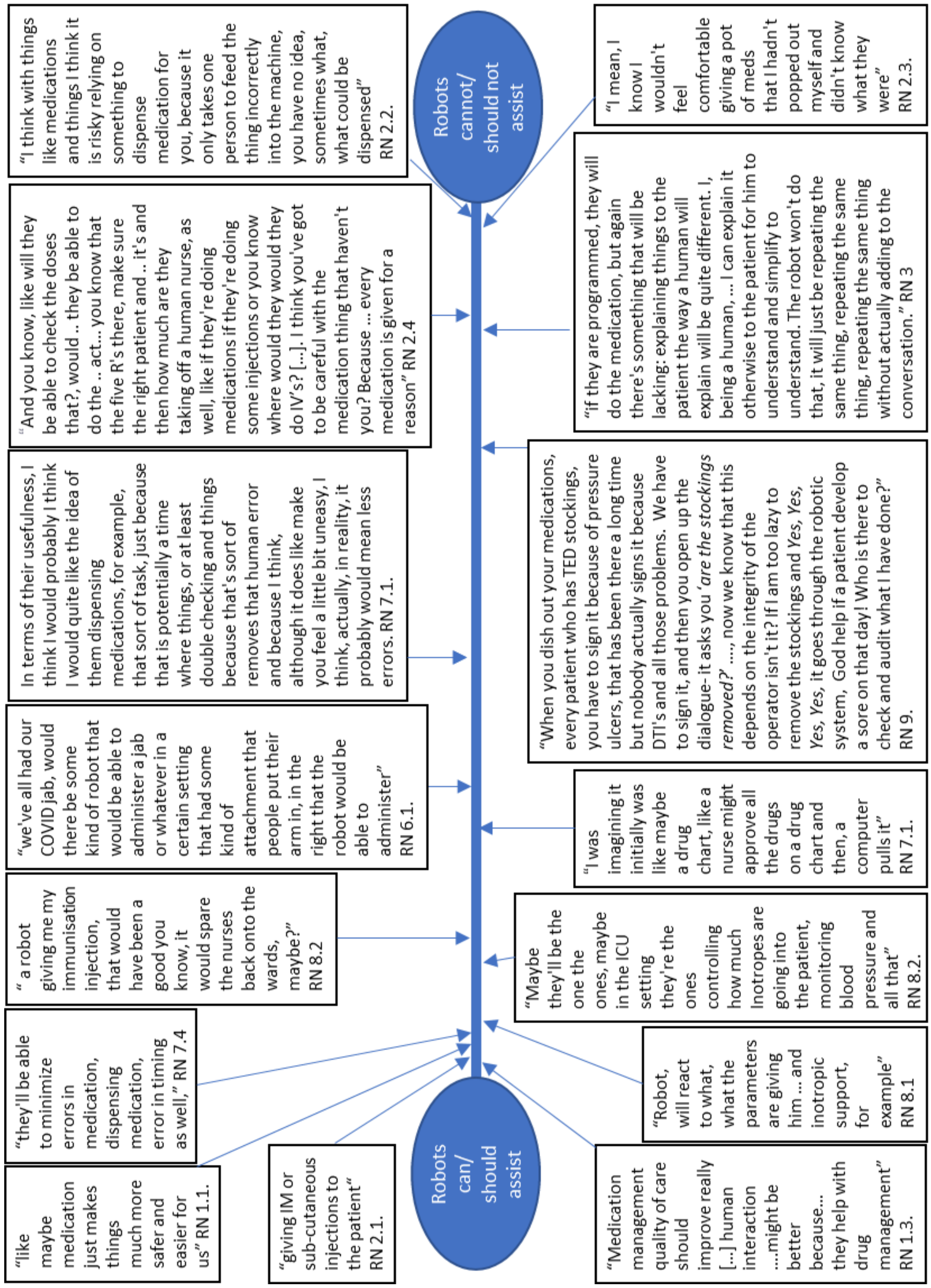


Figure 13.1.4. RN quotes on Robots assisting with Toileting Needs

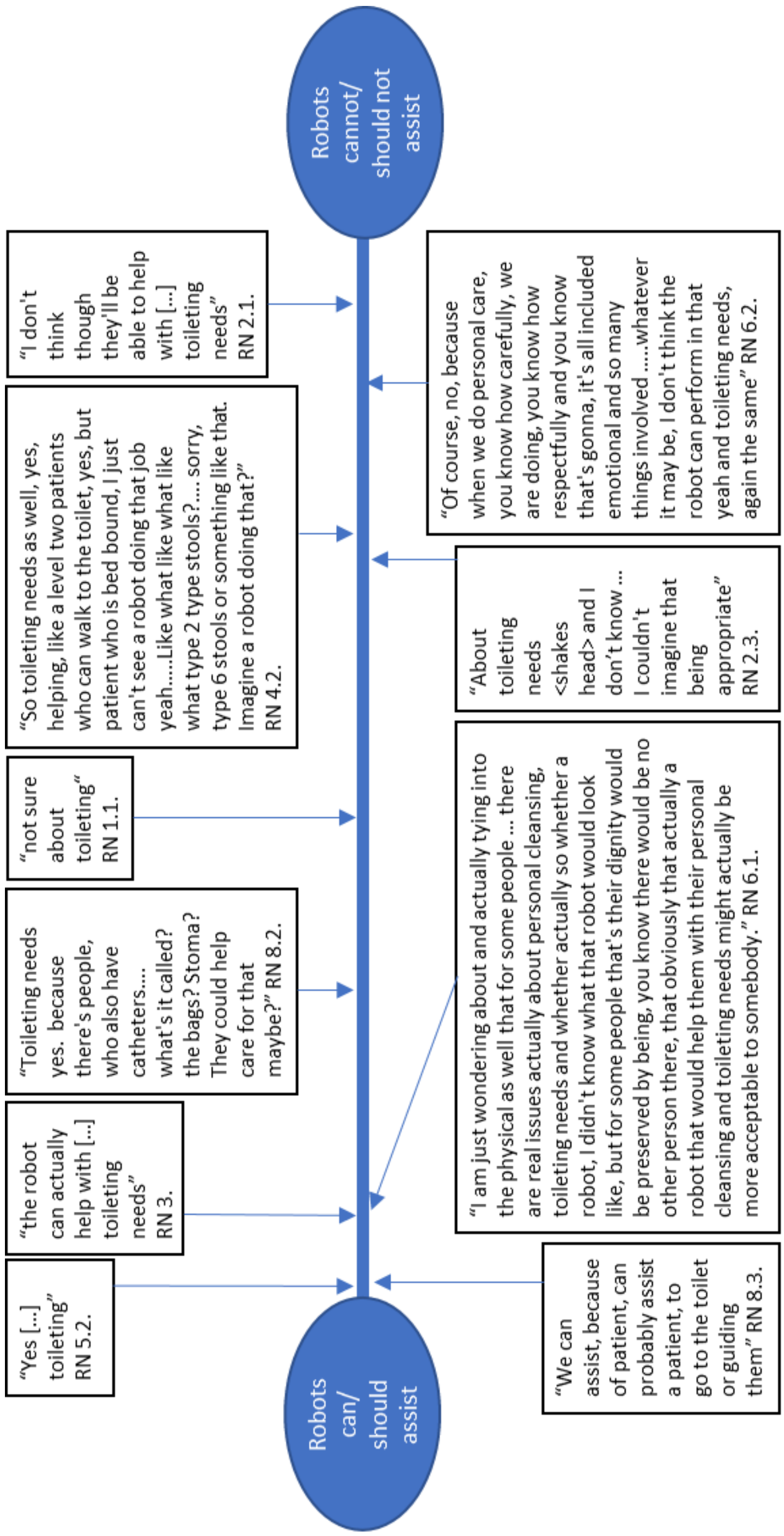


Figure 13.1.5. RN quotes on Robots assisting with Eating and Drinking

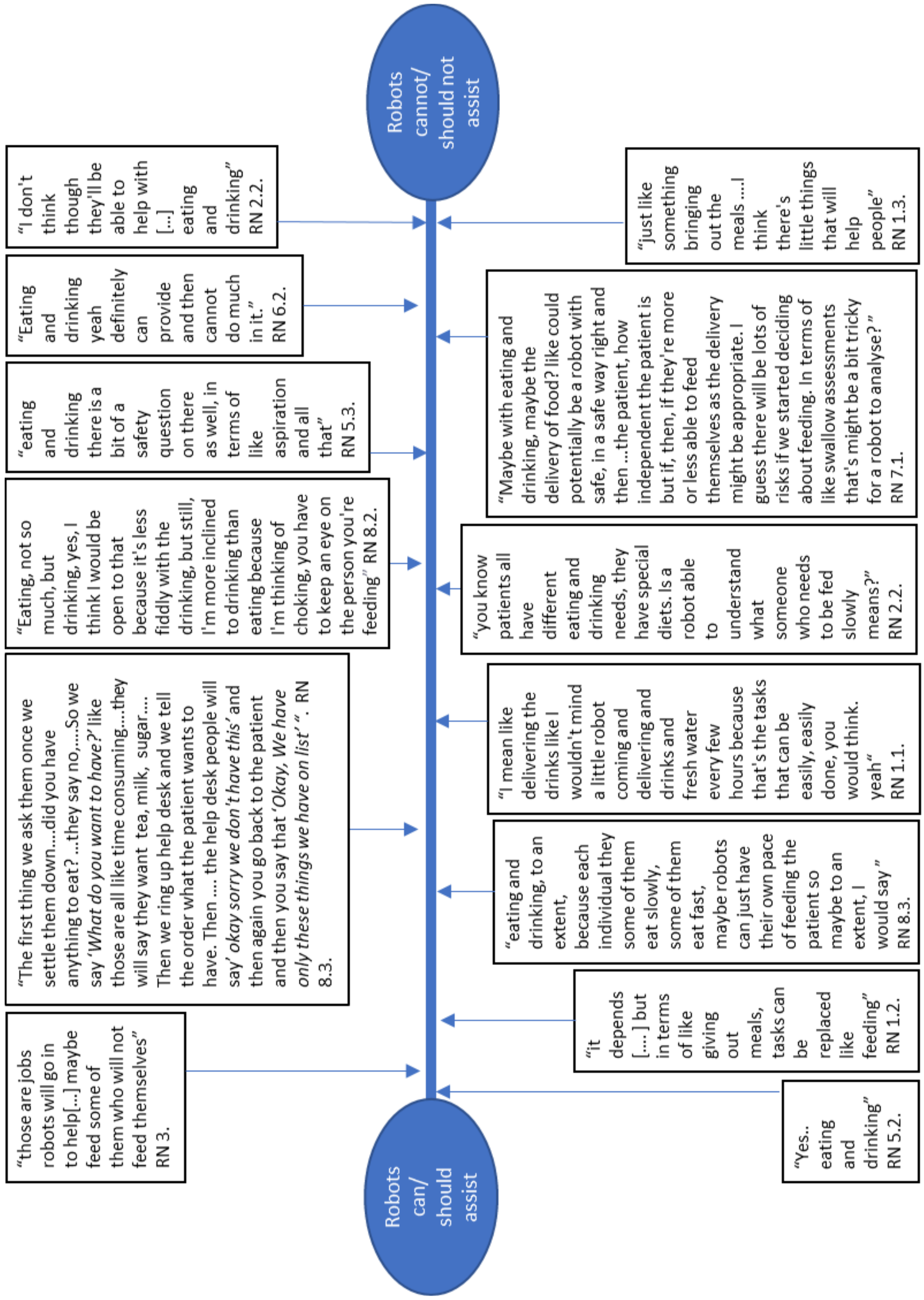


Figure 13.1.6. RN quotes on Robots providing comfort to patients

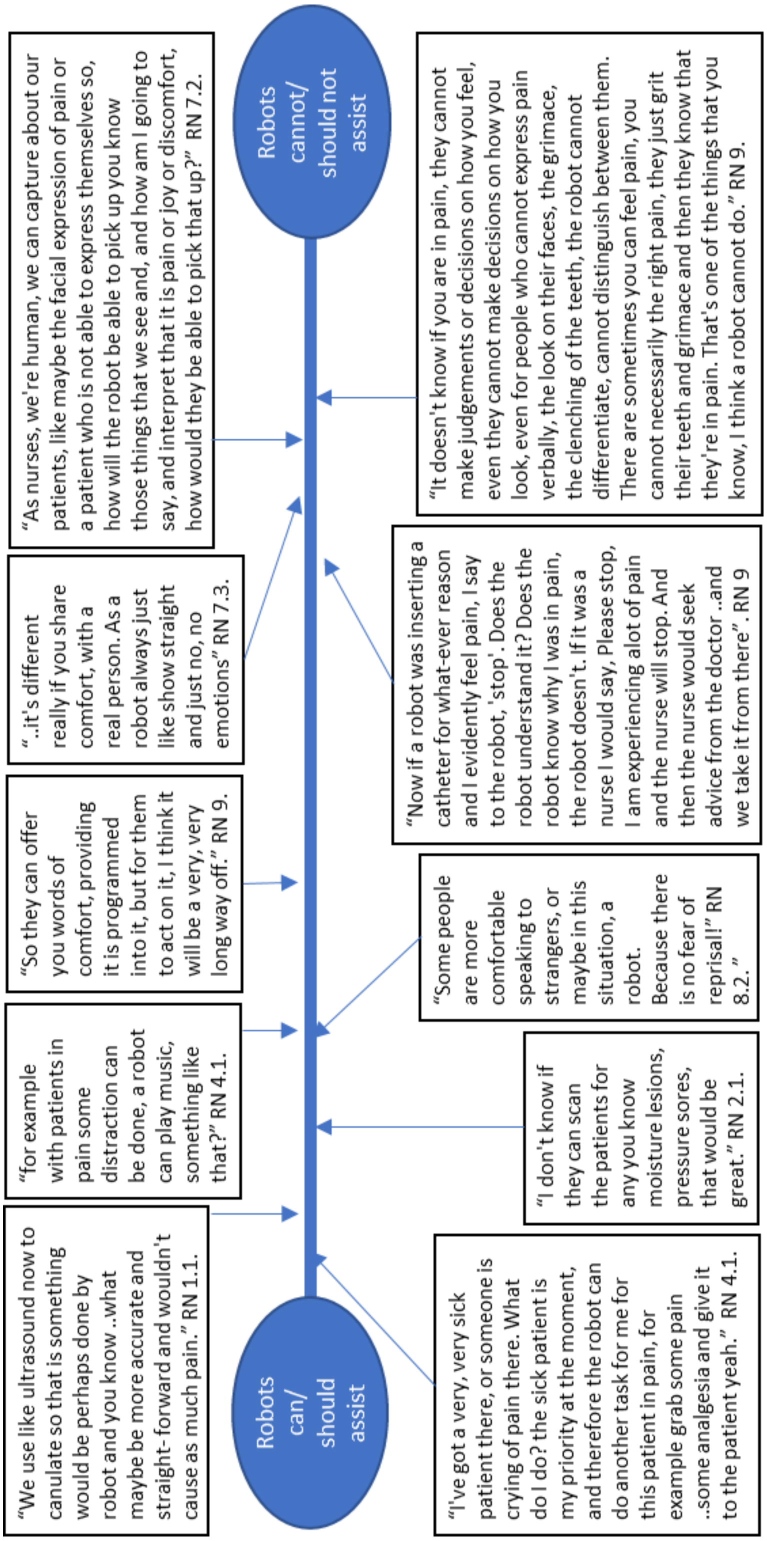


Figure 13.1.7. RN quotes on robots assisting with Patient Safety

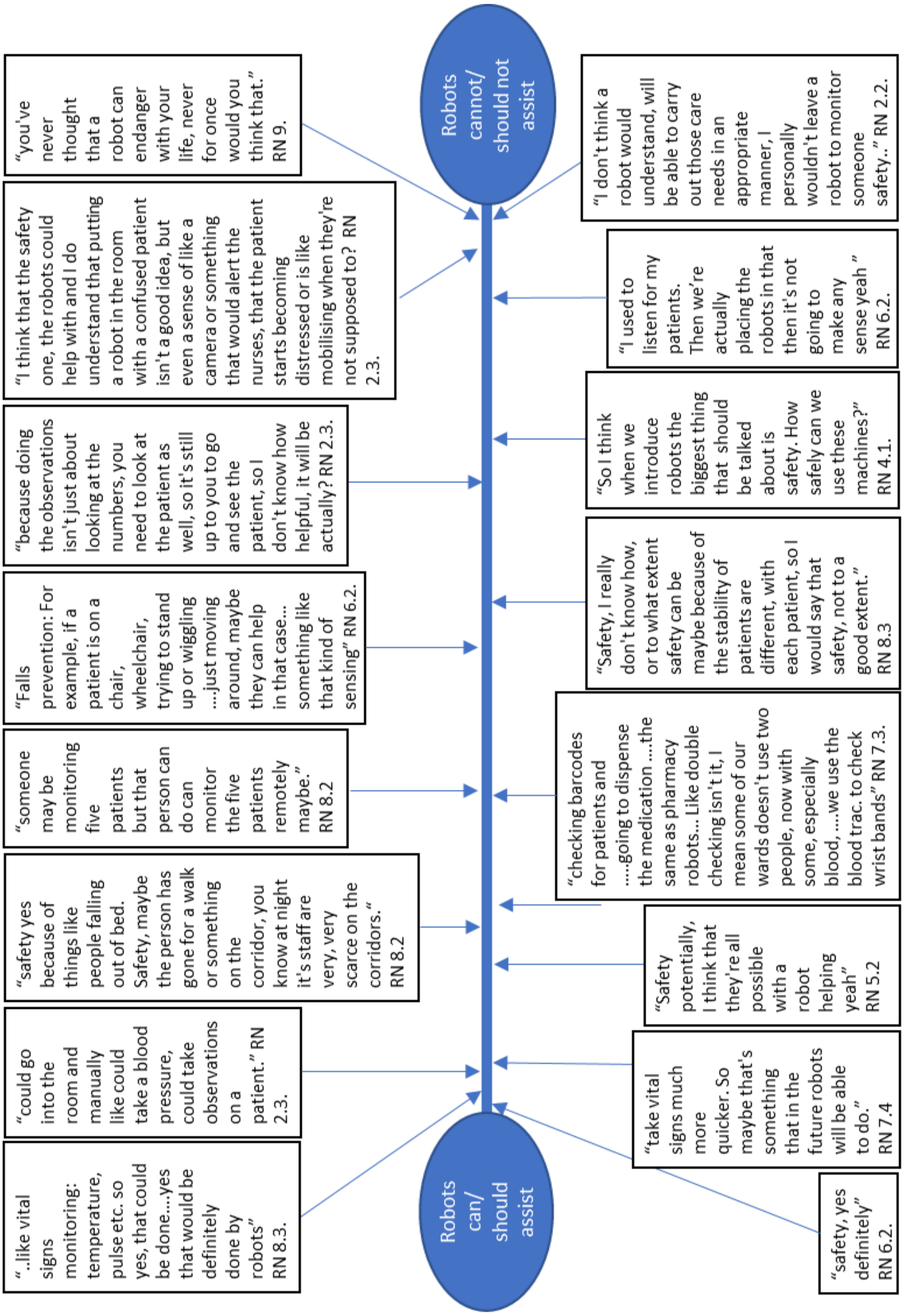
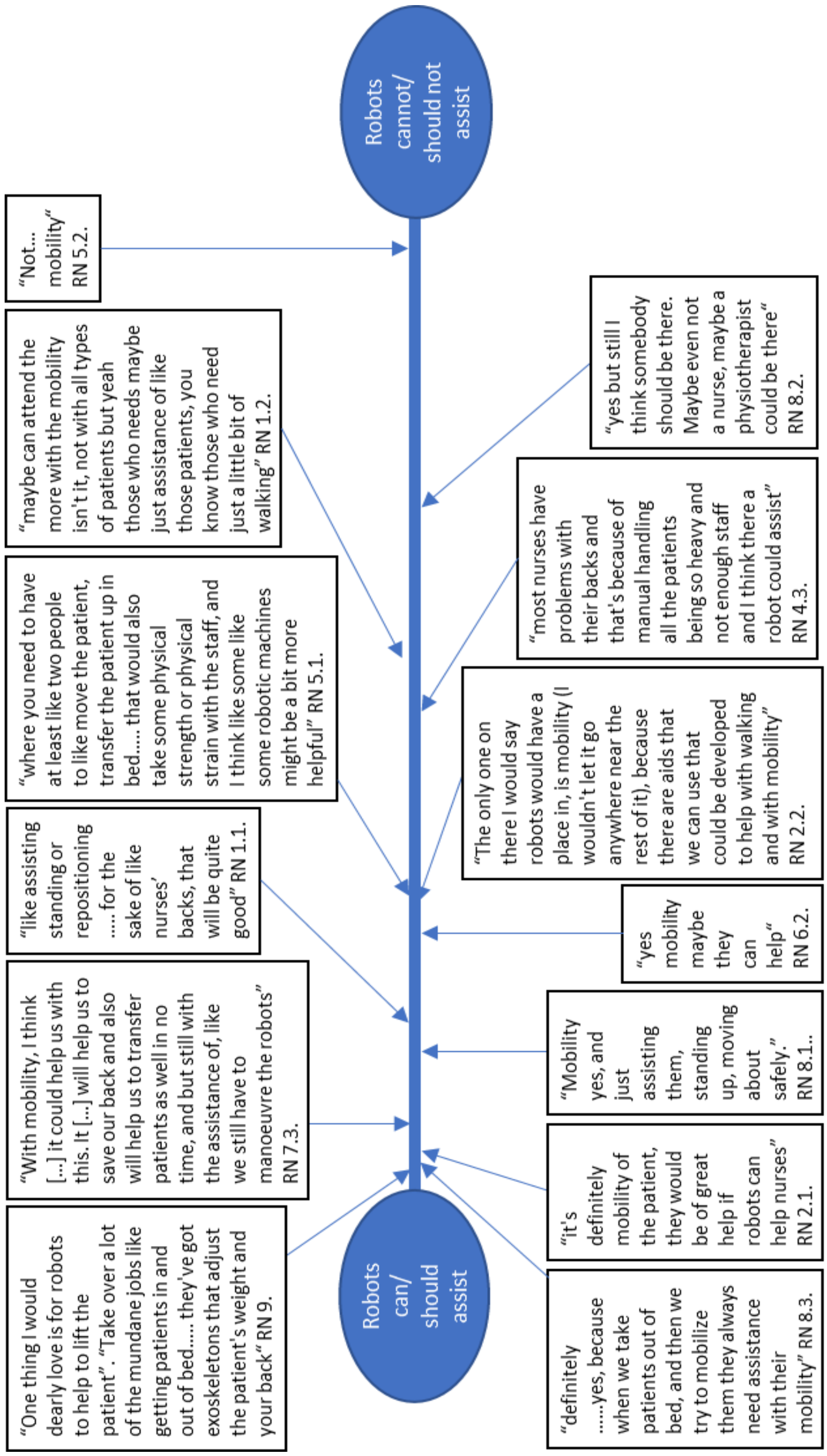


Figure 13.1.8. RN quotes on robots assisting with Mobility



13.2. Psychosocial dimension of FOC Framework

Figure 13.2.1. RN quotes on robots assisting with Communication

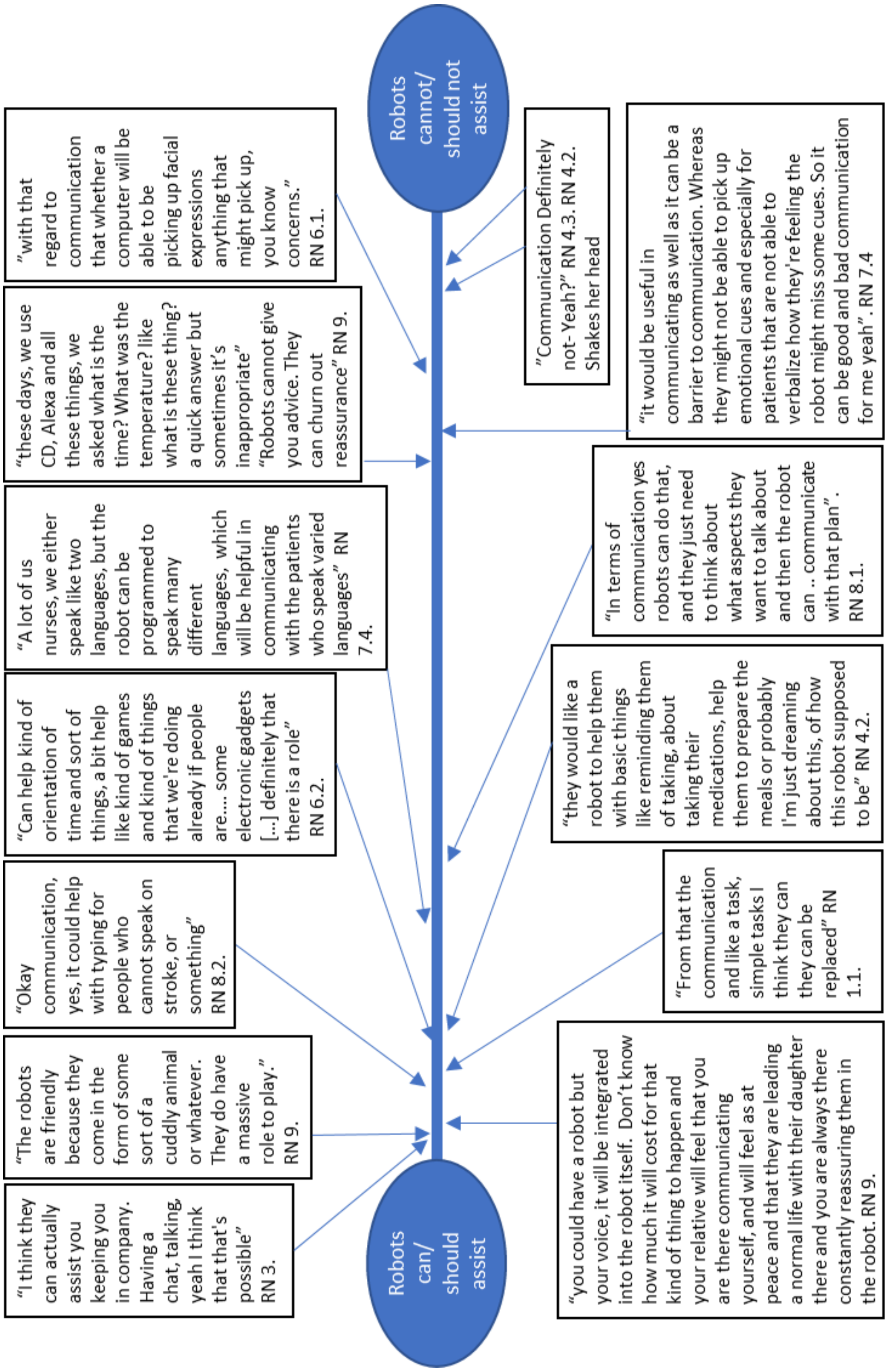


Figure 13.2.2. RN quotes on robots assisting with Education and Information

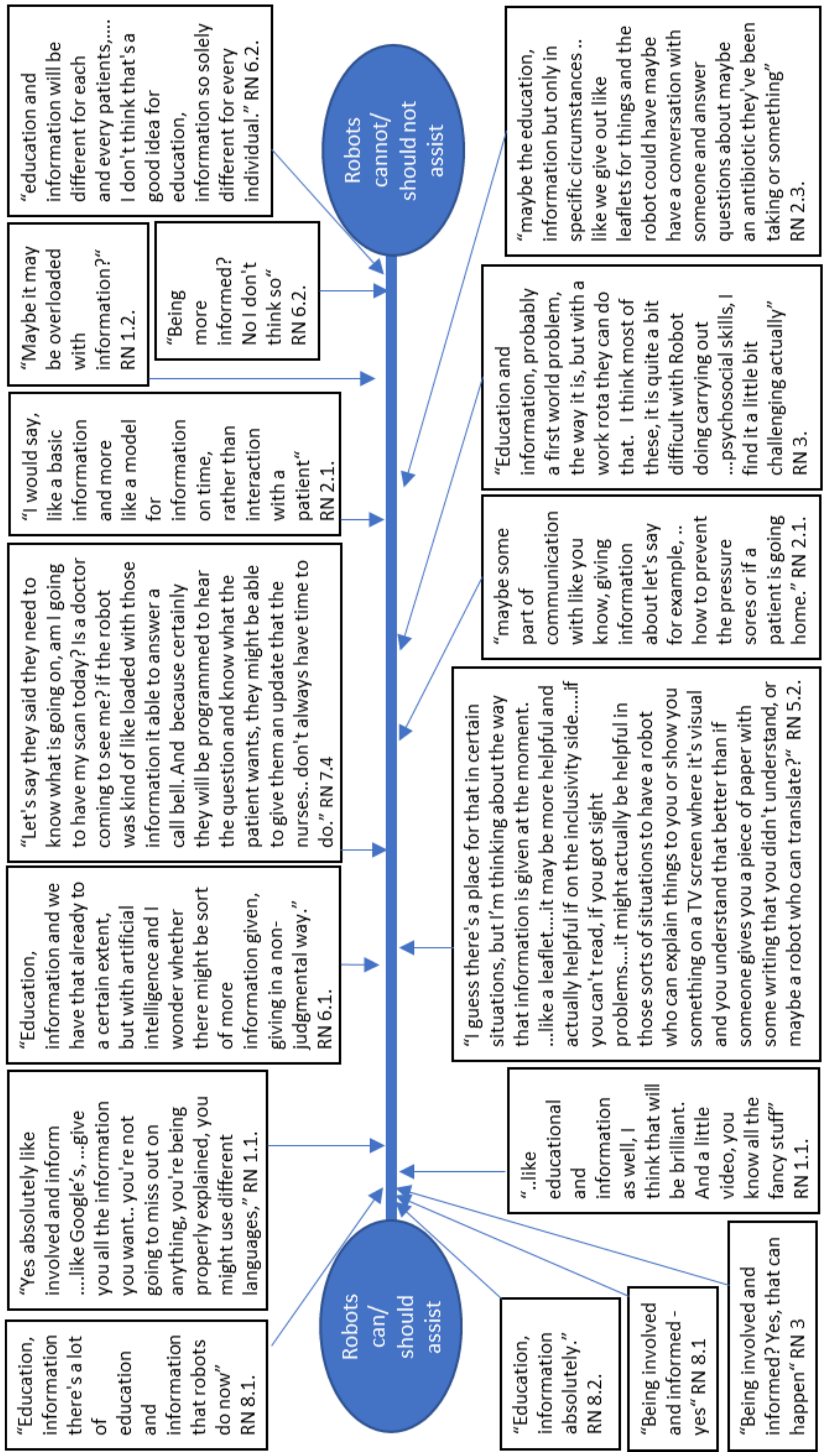


Figure 13.2.3. RN quotes on robots assisting with Privacy, dignity and respect and Having beliefs and values respected.

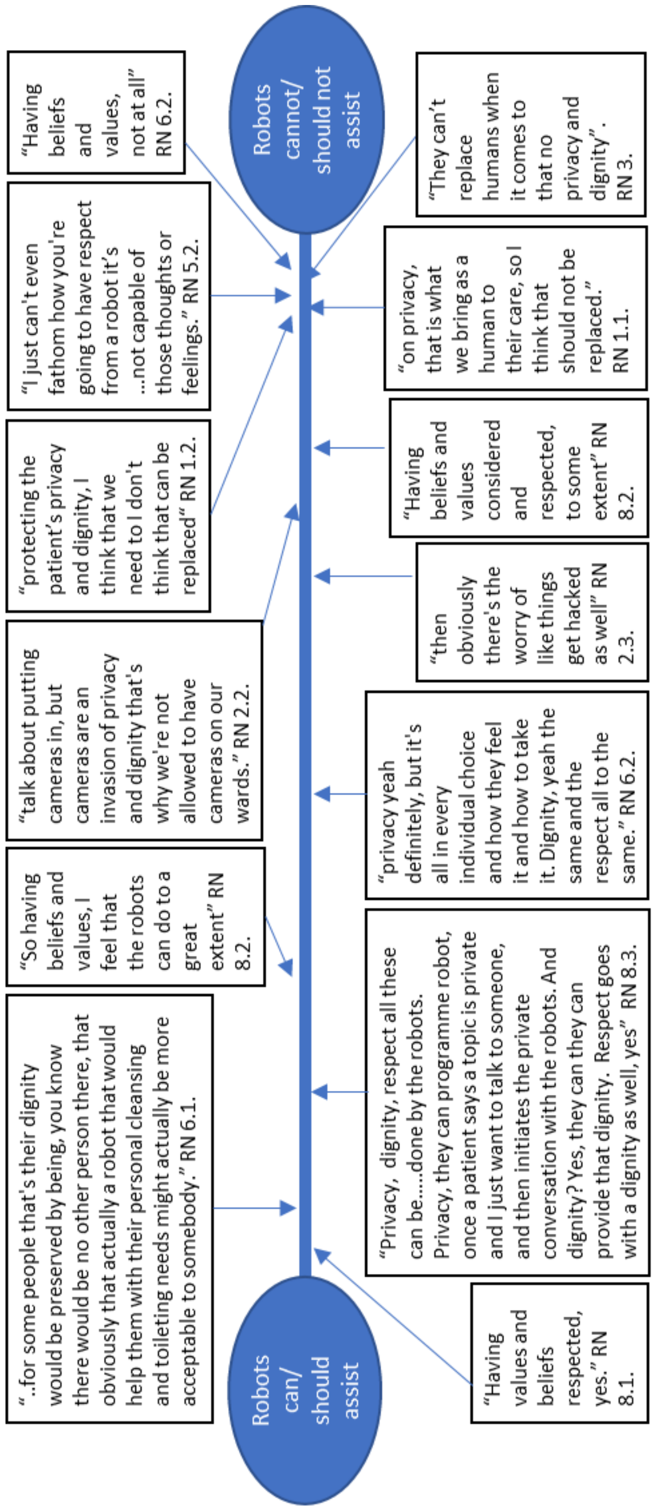
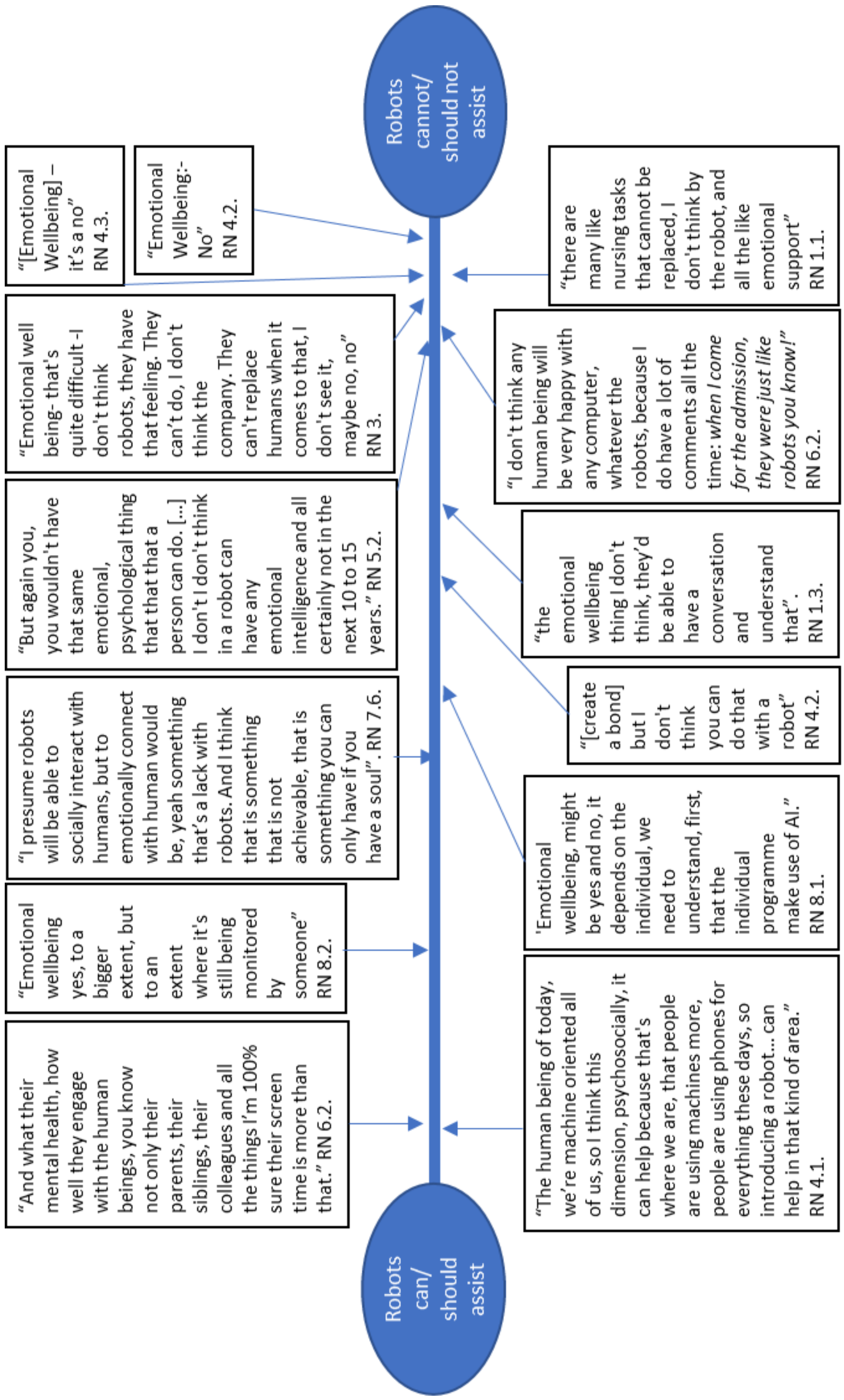


Figure 7.2.4. RN quotes on robots assisting with Emotional Wellbeing.



13.1. Relational dimension of FOC Framework

Figure 13.3.1. RN quotes on robots assisting with Active Listening

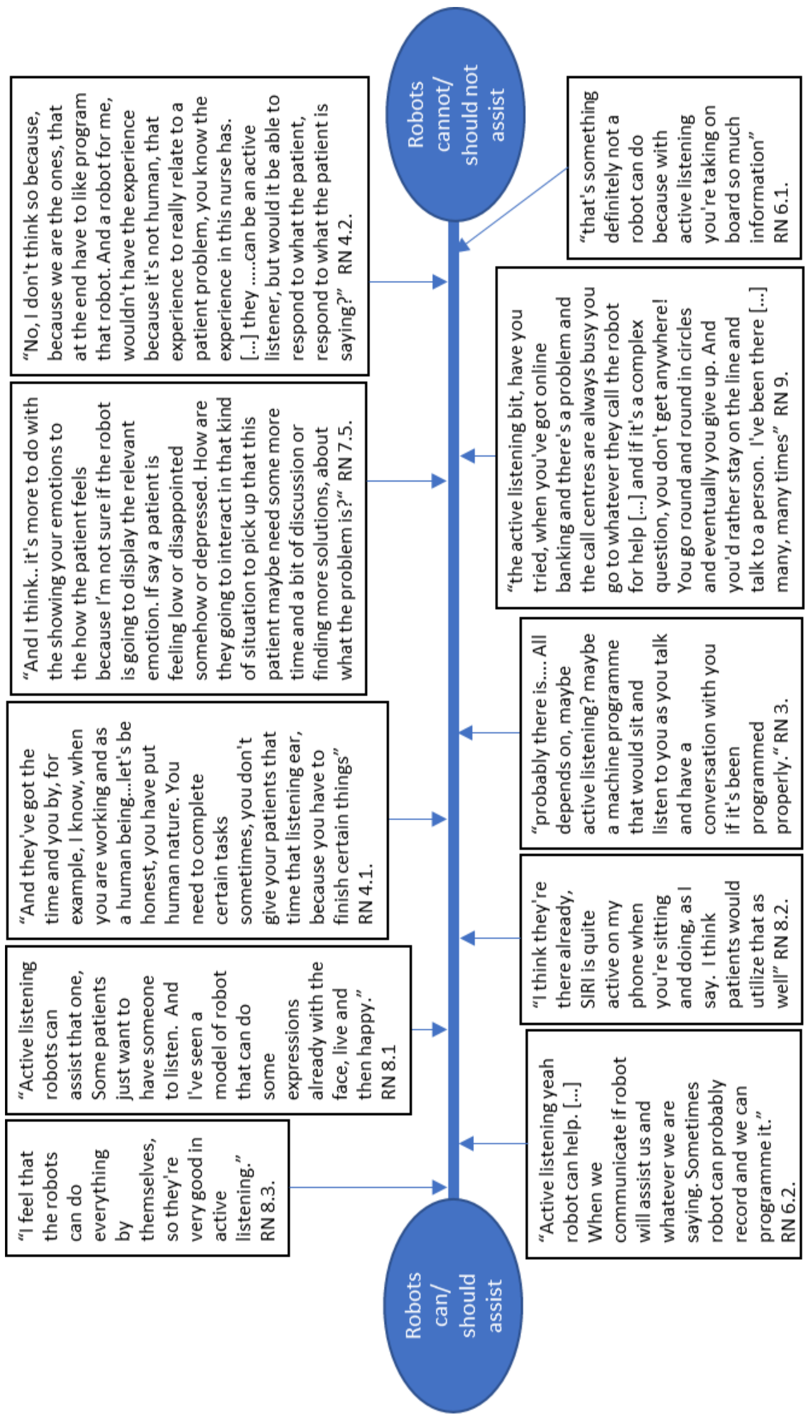


Figure 13.3.2. RN quotes on robots assisting with Empathy and Compassion

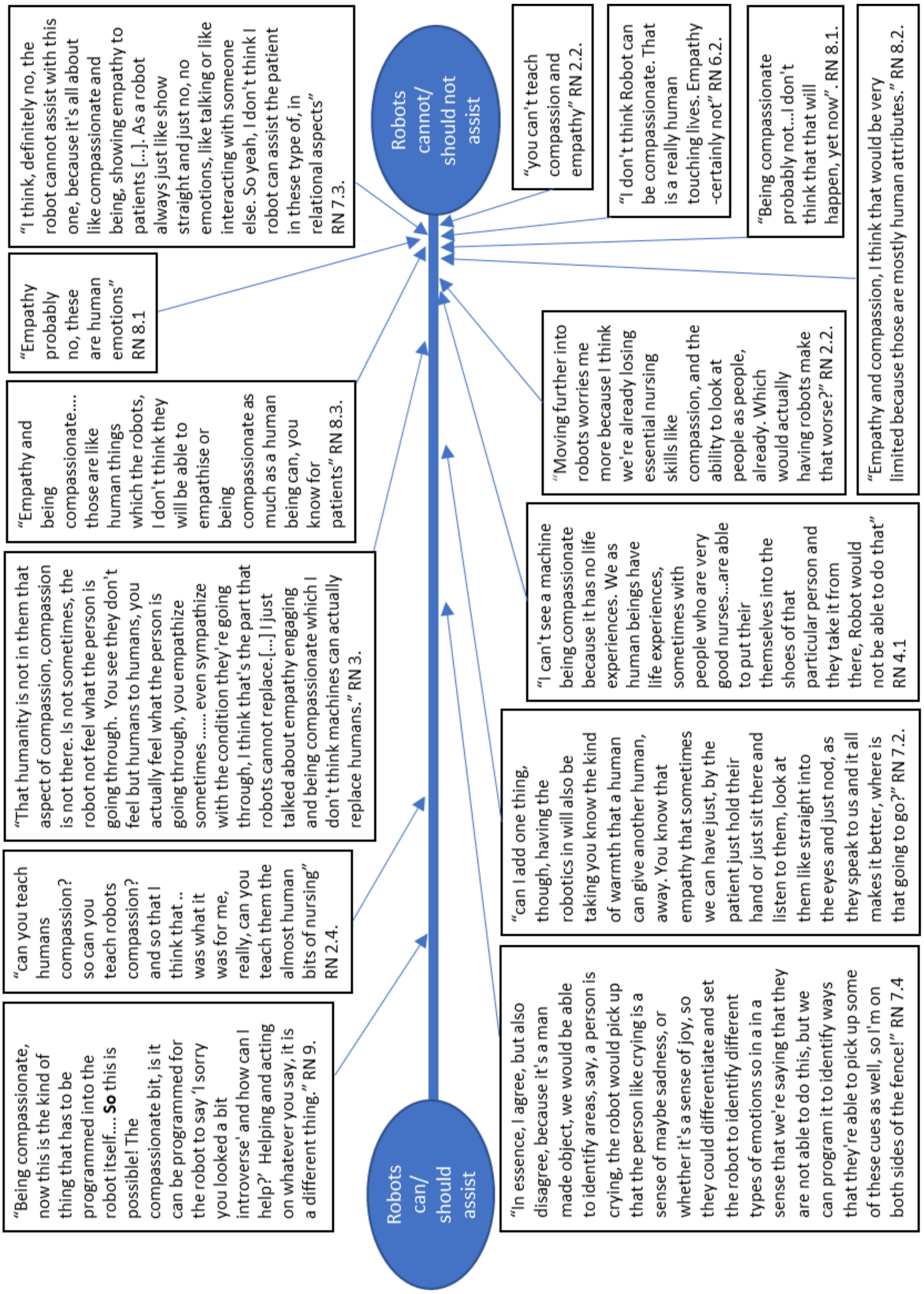


Figure 13.3.3. RN quotes on robots assisting with being present and with patients

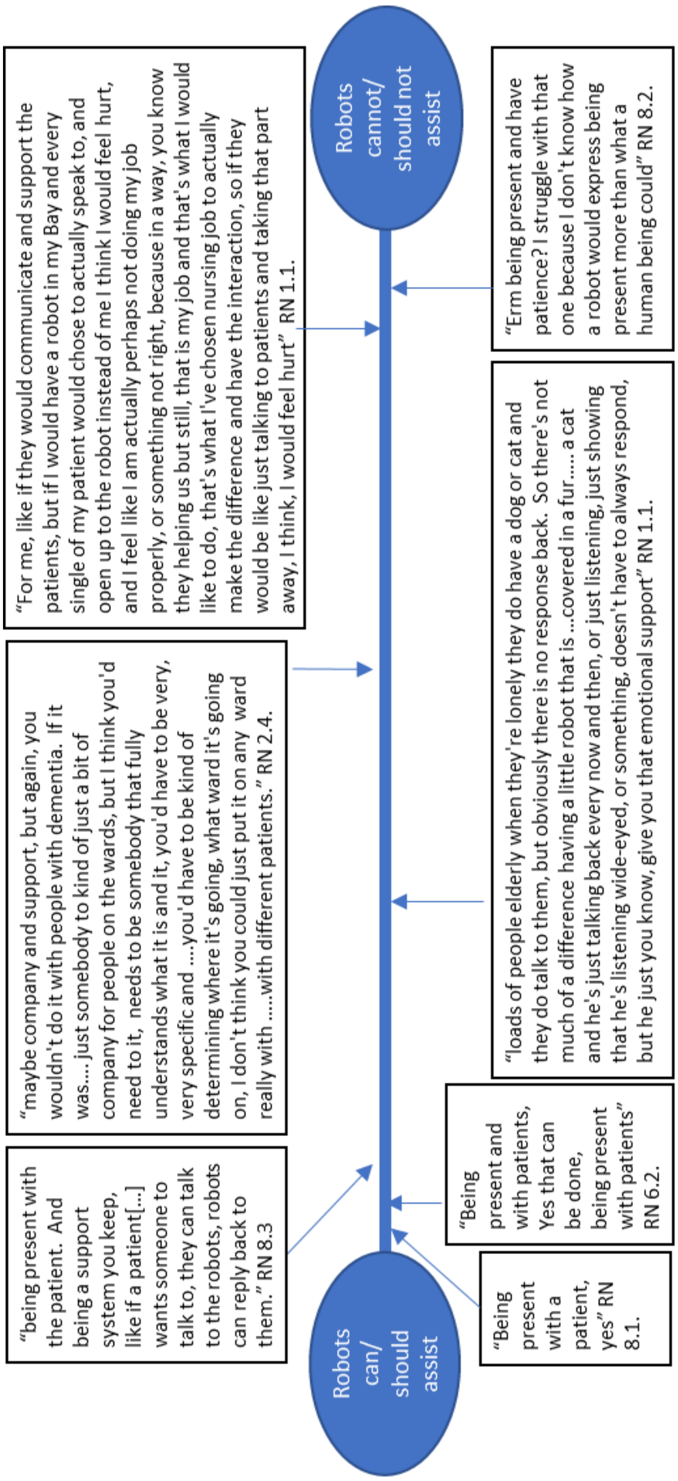


Figure 13.3.4. RN quotes on robots assisting with Engaging with Patients

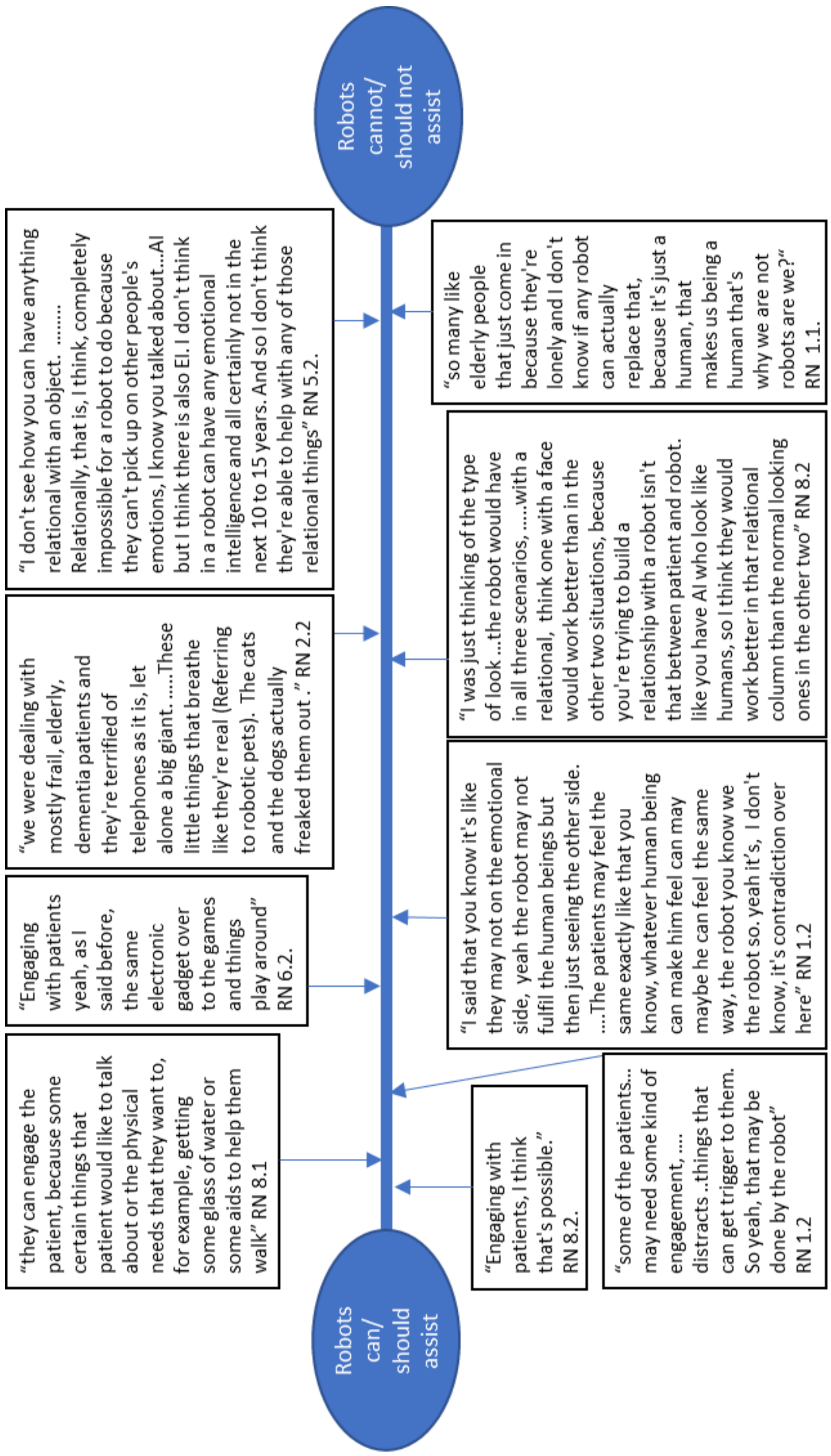


Figure 13.3.5. RN quotes on robots assisting with supporting and involving Families and Carers

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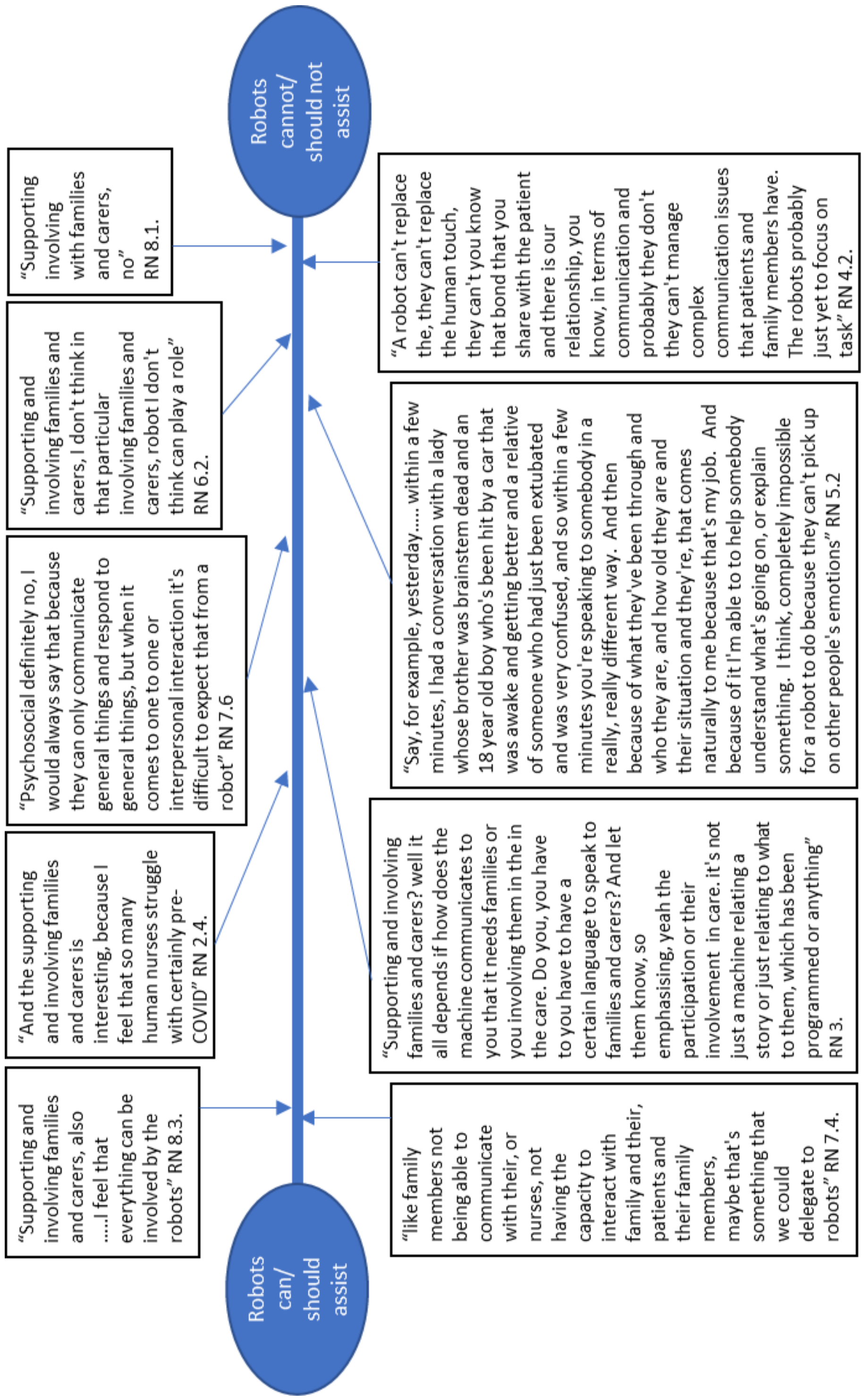


Figure 13.3.6. RN quotes on robots assisting with helping patients to cope and to stay calm.

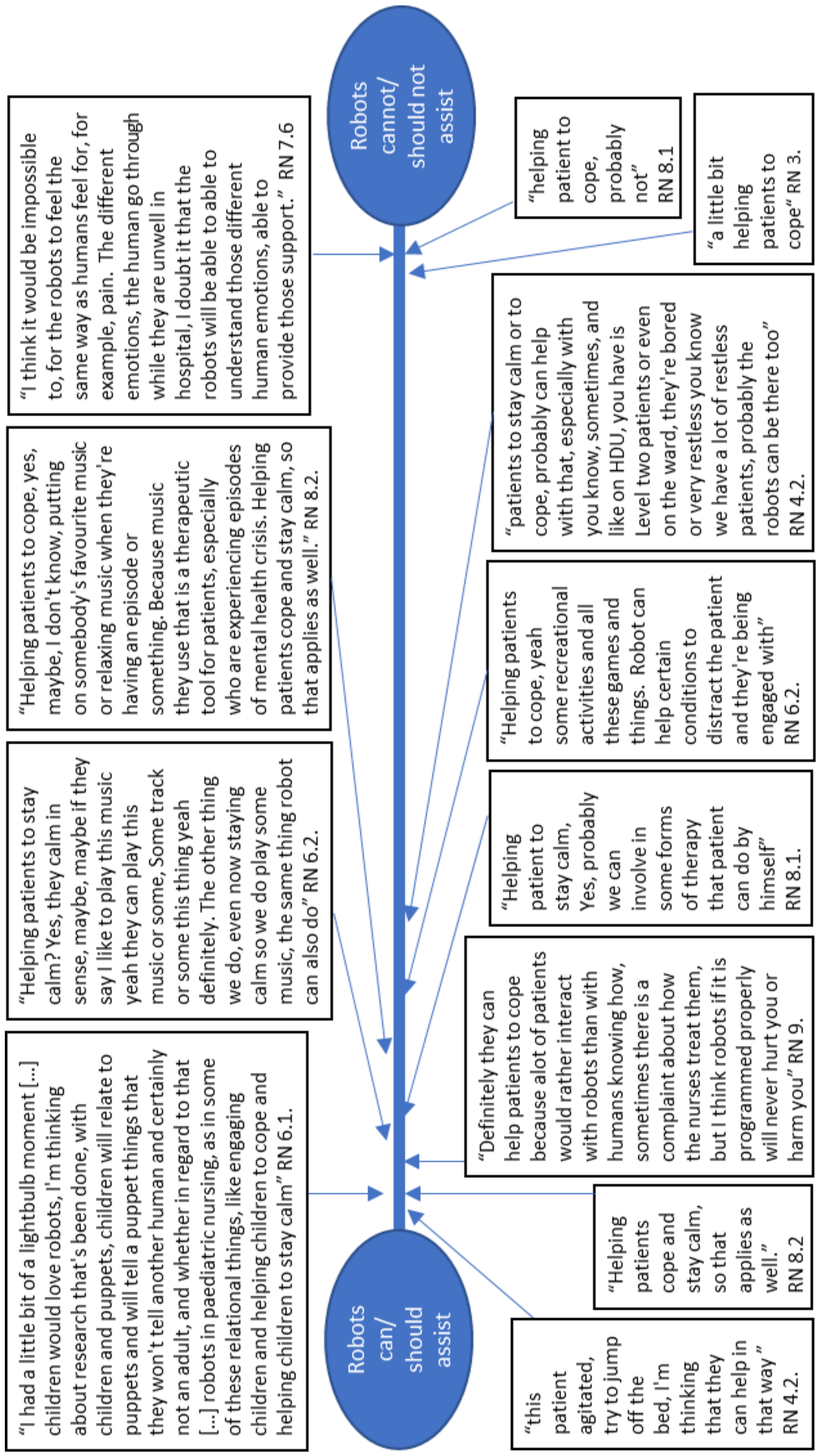


Figure 13.3.7. RN quotes on robots working with patients to set, achieve and evaluate progression of goals.

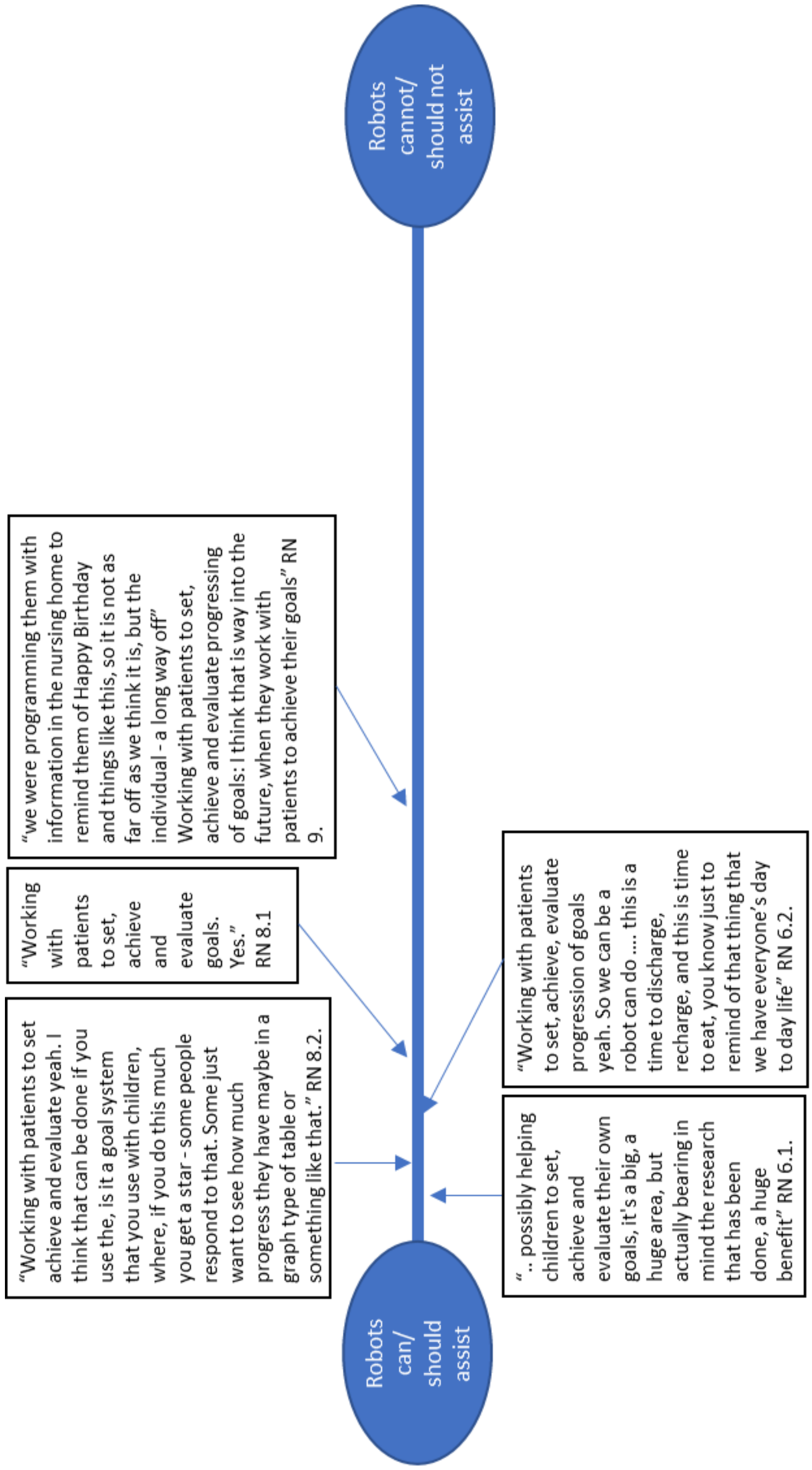
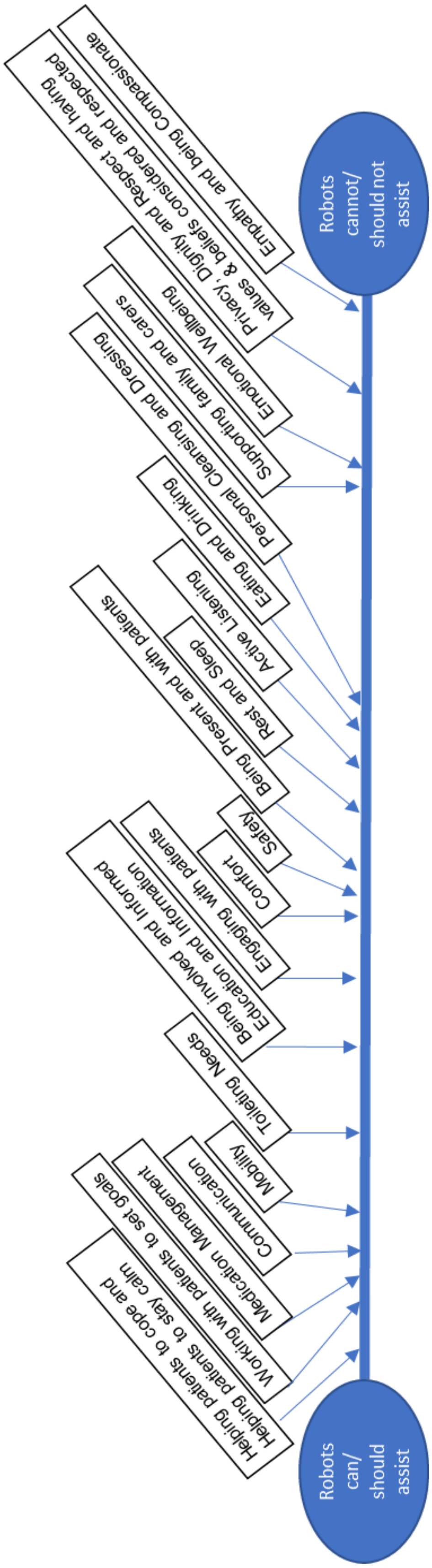


Figure 7.4. Summary of FOC activities that robots can/cannot/should/should not assist with.



Appendix 14. Reflections from Nurse Leader Focus Group

Facilitation of Chief Nurses FG 1
Only two people joined (3 had confirmed plus 1 possible). Was able to go through all material and get comments within one hour.
As facilitator I did comment on issues raised before i.e. substitution and robots not needing sick leave, maternity leave etc which may have dissuaded further comment but doesn't appear so- more interaction seen between participants i.e. building on answers.
Some clear concerns about robotic capability and therefore robots can't (more passive voice) but also a clear steer and suggestion of urgency to look at topic, concerns re impact on nursing as a profession and to have nursing involvement in design and testing. As facilitator – could have been more concise in presentation of previous work.
After this focus group I was disappointed personally that I thought I'd seen evidence of a passive voice from senior leaders, pointing to a future where robots might be designed and imposed- I resolved to suspend this 'judgement' until completing the analysis.

Analysis of FG 1
I rewatched the video again before starting coding. When coding I noticed in coding a tendency to move towards theme generation early on and needed to consciously identify code labels for each part of text.
I labelled one phrase as 'implicit resistance' then challenged myself on whether I harboured an implicit resistance to robots.
Certainly in the planning stages of the study this was true, but as I progressed the study this changed into an intense curiosity into how robots might enable nurses to reclaim the essence of nursing by working alongside robots. I reviewed the audio-visual and paid close attention to my verbal and non verbal behaviour checking that I had not responded more positively to some comments than others. I had managed to respond almost universally with 'great that's helpful' to all contributions.
In terms of the passive voice- there was some passivity in some of the phrasing of robot design and capability but this was balanced by a sense of urgency to contribute to the debate both of which were recorded as codes.

Facilitation of Chief Nurses FG 2
Three senior nurses joined and this was more of a discussion between participants.
It was particularly striking how the two chief nurses started by stating (in different ways) that they couldn't envisage any role for robots in a ward context but by the end were identifying multiple examples of how robots could assist. This group identified parallels with the debates on new roles such as the nursing associate and the reductionist or chunking up of nursing tasks. There was a significant amount of mention about the unique contribution of the nurse and I wondered if this might be one of the themes. I was conscious that I could have explored more what they meant by the unique contribution but I also needed to balance this with time. However I also talked more in this focus group and there was a curiosity in asking me about my interviews.
Despite talking more which is usually an opportunity for self critique, I was hugely encouraged particularly as one of the participants articulated that this stating that as senior nurses there are not enough of these discussions.

Analysis of Chief Nurses FG 1
Again I rewatched the video before coding and was struck again by the level of consensus building amongst the participants which reinforced the need to report on the non verbal data.
As I manually coded there were a number of code labels that were almost concepts –such as substitution and reductionist thinking but also I was particularly struck by discussion on judgement in both complicated and complex situations. The central focus of this focus group conversation was the need for senior nurses to lead the debate on the unique contribution of nursing and how consideration of the role of robots in nursing requires a consideration of what nursing is.
Following coding I need to return to the previous focus group and re-code some of the code labels as some of the content aligns to this focus group too, so perhaps I should watch the remaining 2 videos, then manually code then code into NVIVO one after the other.

Facilitation of Chief Nurses FG 3
This two person group yielded a rich discussion, firstly about the definition of a robot and whether RPA should be included, At the time I didn't know what this was needed to looked this up which made me wonder what I had missed in robotic development. This focus group also discussed the unique contribution of the nurse and compared that with other health professionals. Much of the conversation strayed into the wider technological landscape and portrayed an appetite to explore how robots might assist nursing.
The suggestion of robots 'releasing time to care' had echoes of previous work on nursing productivity but was recurring rationale for the exploration of robots in nursing.
Again the unique contribution of the nurse came up and this time I was able to probe a little further into what this meant.
Interpretation was also discussed in a similar way to the discussion of judgement in the previous focus group. My facilitation of this focus group was complicated by the late arrival of one person (late start), meaning there was less time to discuss roles of robot.

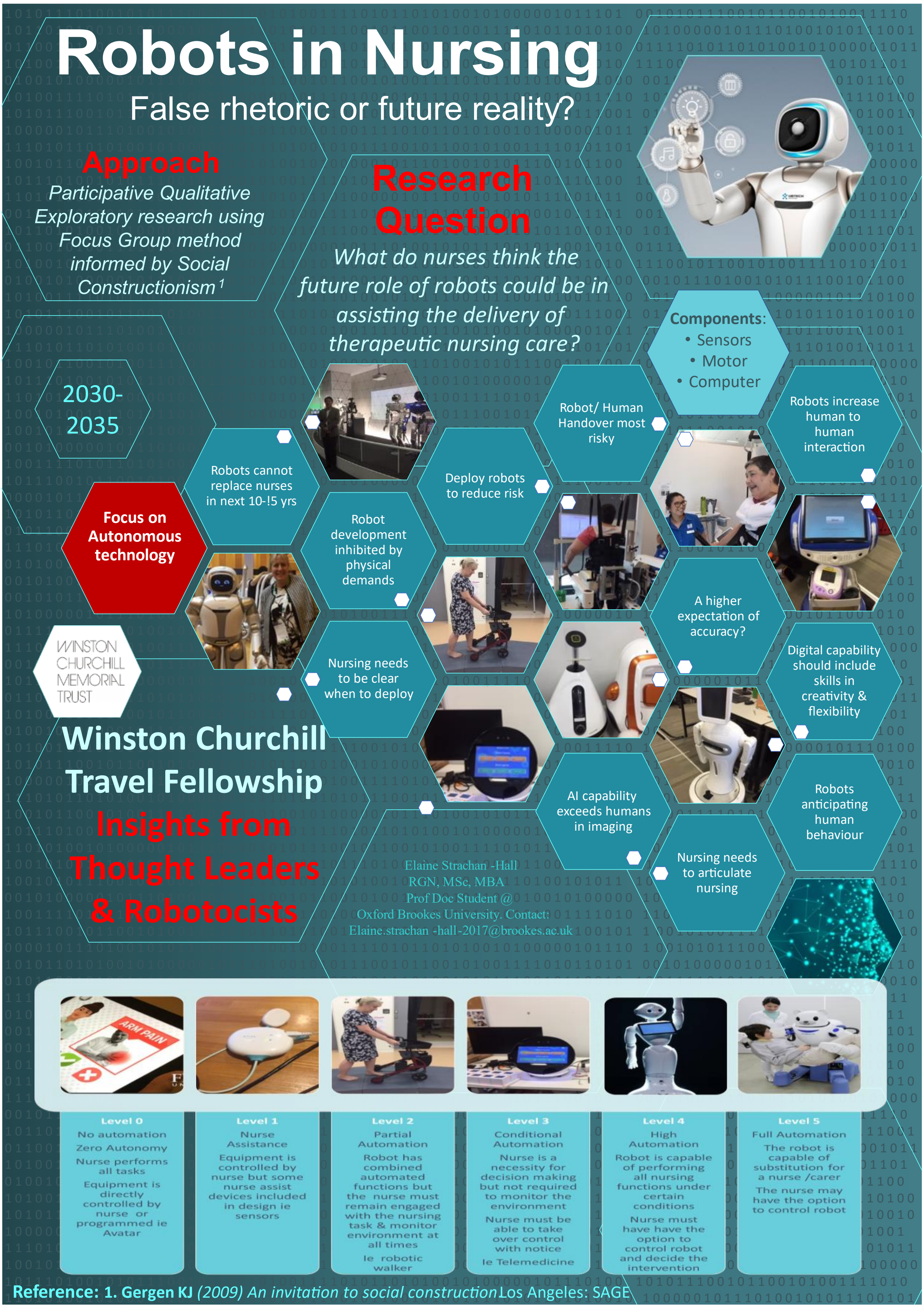
Analysis of Chief Nurses FG 3
Rewatching the video I noted a clear articulation of being involved and an openness to thinking through the issues and a similar degree of reflection amongst the participants.
I coded this focus group the day after watching the last two focus group videos and noticed that I was coding in labels, i.e. I was trying to fit a pre-existing label to the text. I therefore did a second review of the transcript to make sure I had captured the need for additional codes.
The use of the NVIVO search function in the second round of coding assisted in looking at consistency of previous coding for aspects such as robots 'releasing time'.
This focus group majored on harnessing the 'adjunct' or 'complementary' support that robots might have and the manner of discussion came across as an active commitment for development in this area, perhaps because of the background of the participants (national leadership).

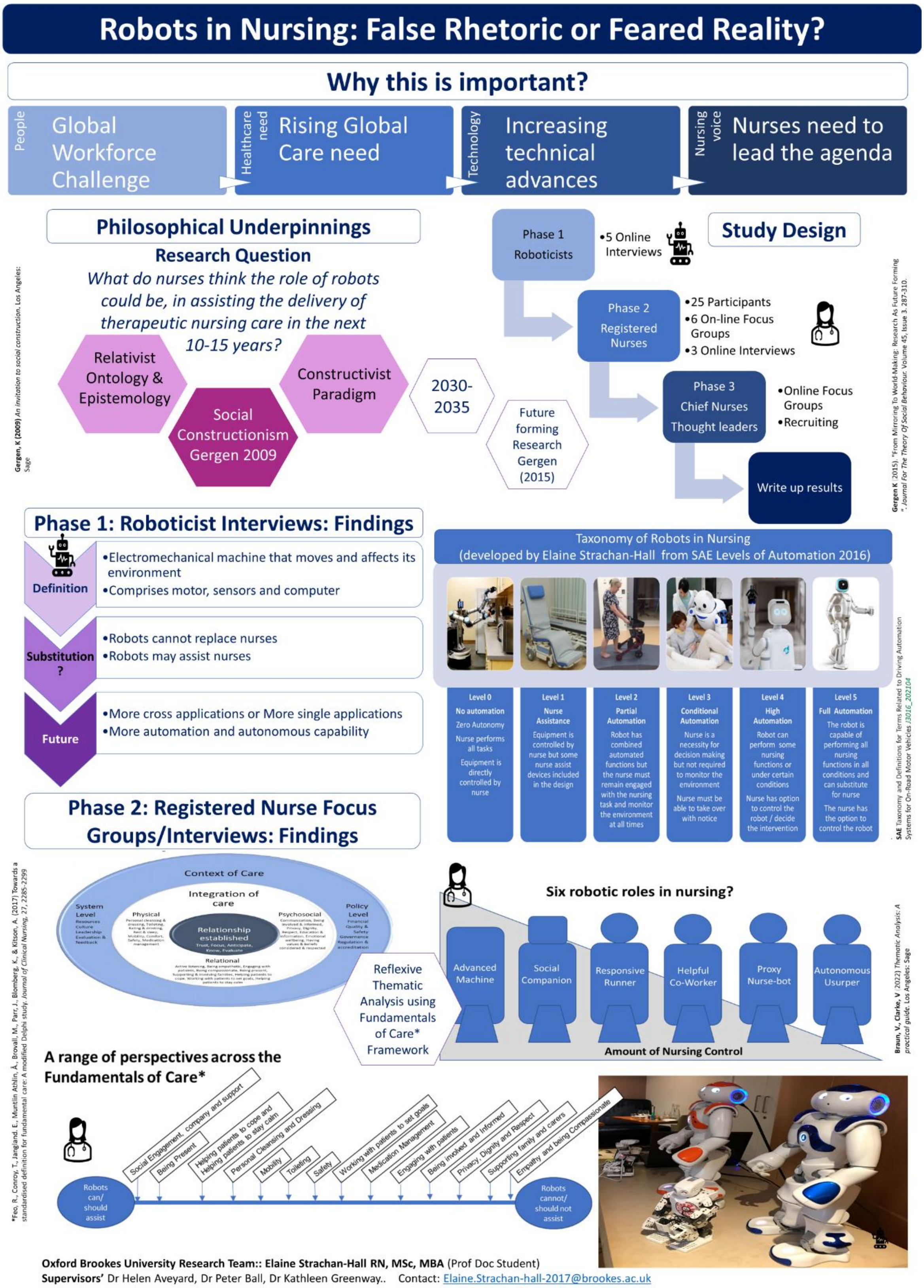
Facilitation of Chief Nurses FG 4
This focus group comprised 5 participants and was the most challenging to facilitate, perhaps due to the number of participants (meaning we had little time to discuss the roles) and perhaps exacerbated by difference in participant background. Two had Trust CNIO roles and were positioned early in the focus group (by one of the CNIOs) as the technical people in the room. The definition of a robot excluding RPA was more overtly challenged and I felt this as a criticism. I thought 'I'm in year 6 or 5 years of study and perhaps I have conducted all these focus groups based on an incorrect premise'. I subsequently discussed this important challenge with supervisors including the subject matter expert concluding that the use of robotic processes does not necessarily mean an entity is a robot.
This focus group had some good discussion on the difficulties of moving from evidence of value to practice adoption and the importance of how robotic assistance is presented. I felt a little deflated after this focus group, thinking I should have managed the time better as the discussion about roles was curtailed. It is a learning point in both size and heterogeneity of the group.

Analysis of Chief Nurses FG 4
The sense of deflation extended into the analysis and I was cognisant of a reluctance and procrastination to code this group.
During coding I observed that opinions appeared more developed in advance and there was less evolvement of perspectives through the period of discussion. This was perhaps because of the presence of two digital leaders.
This focus group comprised participants who were prima facie positive about robotic development and who then grappled with thinking through the challenge of implementation. This focus appeared to originate from one of the first contributions outlining an evidenced based robot in phlebotomy that was not in routine use.
Looking back across the focus groups a pattern emerges in that the main theme or focus of each focus group is impacted by the first participant responses.

Appendix 15: Poster Presentations

Winston Churchill Travel Fellowship Poster




Robots in Nursing: False Rhetoric or Feared Reality?
Why this is important?
People
Global Workforce Challenge
Healthcare need
Rising Global Care need
Technology
Increasing technical advances
Nursing voice
Nurses need to lead the agenda
Philosophical Underpinnings
Research Question
What do nurses think the role of robots could be, in assisting the delivery of therapeutic nursing care in the next 10-15 years?
Relativist Ontology & Epistemology
Social Constructionism Gergen 2009
Constructivist Paradigm
2030-2035
Future forming Research Gergen (2015)
Gergen, K (2009) An invitation to social construction. Los Angeles: Sage
Study Design
Phase 1 Roboticists
•5 Online Interviews
Phase 2 Registered Nurses
•25 Participants
•6 On-line Focus Groups
•3 Online Interviews
Phase 3 Chief Nurses Thought leaders
•Online Focus Groups
•Recruiting
Write up results
Gergen K 2015). "From Mirroring To World-Making: Research As Future Forming." Journal For The Theory Of Social Behaviour. Volume 45, Issue 3. 287-310.
Phase 1: Roboticist Interviews: Findings
Definition
•Electromechanical machine that moves and affects its environment
•Comprises motor, sensors and computer
Substitution ?
•Robots cannot replace nurses
•Robots may assist nurses
Future
•More cross applications or More single applications
•More automation and autonomous capability
Taxonomy of Robots in Nursing
(developed by Elaine Strachan-Hall from SAE Levels of Automation 2016)
Level 0 No automation Zero Autonomy Nurse performs all tasks Equipment is directly controlled by nurse
Level 1 Nurse Assistance Equipment is controlled by nurse but some nurse assist devices included in the design
Level 2 Partial Automation Robot has combined automated functions but the nurse must remain engaged with the nursing task and monitor the environment at all times
Level 3 Conditional Automation Nurse is a necessity for decision making but not required to monitor the environment Nurse must be able to take over with notice
Level 4 High Automation Robot can perform some nursing functions or under certain conditions Nurse has option to control the robot / decide the intervention
Level 5 Full Automation The robot is capable of performing all nursing functions in all conditions and can substitute for nurse The nurse has the option to control the robot
SAE Taxonomy and Definitions for Terms Related to Driving Automation Systems for On-Road Motor Vehicles J3016_202104
Phase 2: Registered Nurse Focus Groups/Interviews: Findings
Context of Care
Integration of care
System Level
Policy Level
Physical
Psychosocial
Relationship established
Relational
Reflexive Thematic Analysis using Fundamentals of Care* Framework
Six robotic roles in nursing?
Advanced Machine
Social Companion
Responsive Runner
Helpful Co-Worker
Proxy Nurse-bot
Autonomous Usurper
Amount of Nursing Control
Braun, V., Clarke, V. 2022) Thematic Analysis: A practical guide. Los Angeles: Sage
A range of perspectives across the Fundamentals of Care*
Robots can/ should assist
Social Engagement, company and support
Being Present
Helping patients to cope and Helping patients to stay calm
Personal Cleansing and Dressing
Mobility
Toileting
Safety
Working with patients to set goals
Medication Management
Engaging with patients
Being involved and informed
Privacy, Dignity and Respect
Supporting family and carers
Empathy and being Compassionate
Robots cannot/ should not assist
*Feo, R., Conroy, T., Jangland, E., Muntlin Athlin, Å., Brovall, M., Parr, J., Blomberg, K., & Kitson, A. (2017) Towards a standardised definition for fundamental care: A modified Delphi study. Journal of Clinical Nursing, 27, 2285-2299
Oxford Brookes University Research Team:: Elaine Strachan-Hall RN, MSc, MBA (Prof Doc Student)
Supervisors' Dr Helen Aveyard, Dr Peter Ball, Dr Kathleen Greenway.. Contact: Elaine.Strachan-hall-2017@brookes.ac.uk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Relativist Ontology & Epistemology
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Contact: Elaine.Strachan-Hall-2017@brookes.ac.uk
Research Team:
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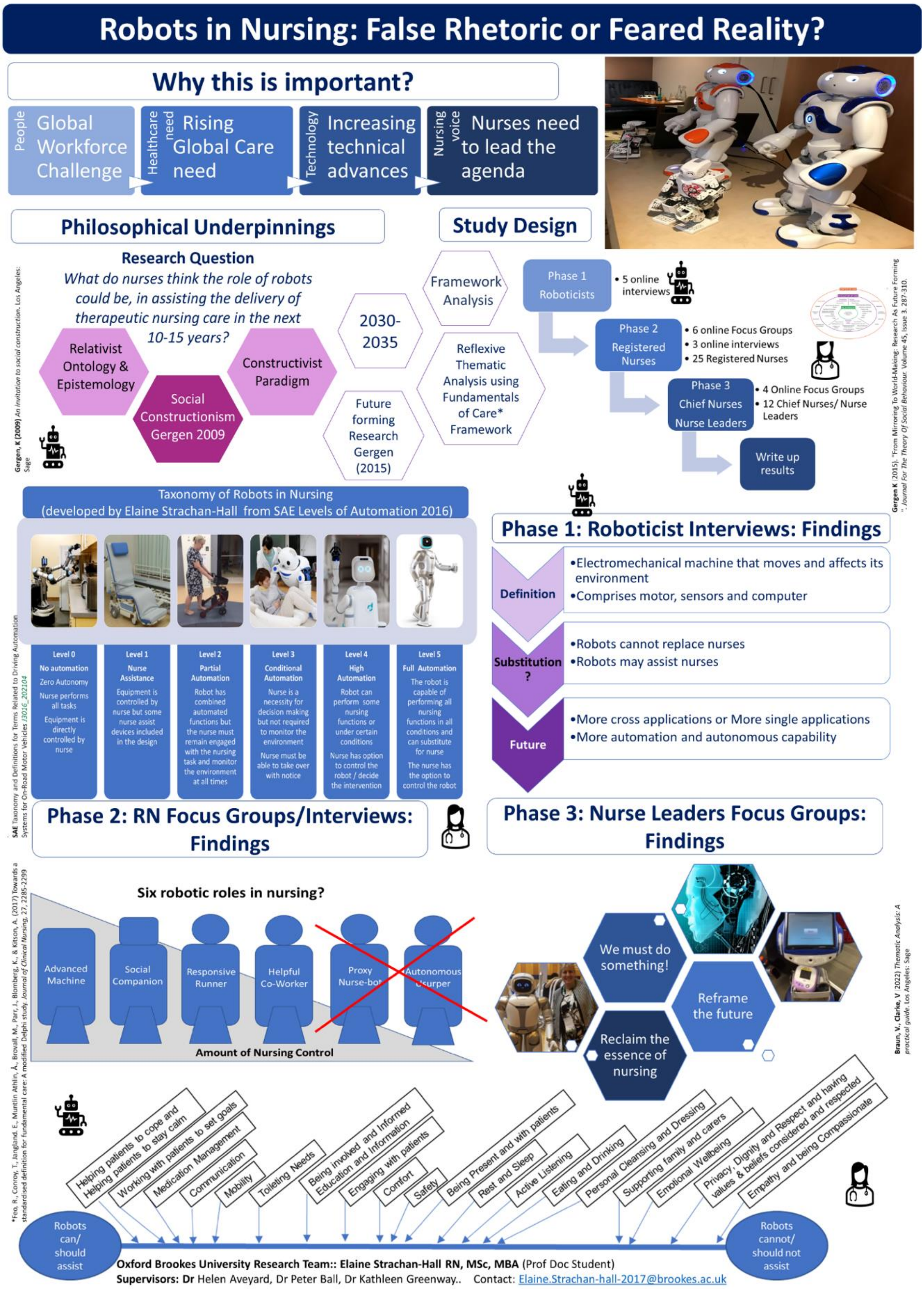
(Prof Doc Student),
Supervisors:
Dr Helen Aveyard,
Dr Peter Ball,
Dr Kathleen Greenway, Oxford Brookes University.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Helpful Co-Worker
Proxy Nurse-bot
Autonomous Usurper
Amount of Nursing Control
Phase 3: Nurse Leaders Focus Groups: Findings
We must do something!
Reframe the future
Reclaim the essence of nursing
Braun, V., Clarke, V (2022) Thematic Analysis: A practical guide. Los Angeles: Sage
Helping patients to cope and
Helping patients to stay calm
Working with patients to set goals
Medication Management
Communication
Mobility
Toileting Needs
Being involved and Informed
Education and Information
Engaging with patients
Comfort
Safety
Being Present and with patients
Rest and Sleep
Active Listening
Eating and Drinking
Personal Cleansing and Dressing
Supporting family and carers
Emotional Wellbeing
Privacy, Dignity and Respect and having values & beliefs considered and respected
Empathy and being Compassionate
Robots can/ should assist
Robots cannot/ should not assist
*Feo, R., Conroy, T., Jangland, E., Muntlin Athlin, Å., Brovall, M., Parr, J., Blomberg, K., & Kitson, A. (2017) Towards a standardised definition for fundamental care: A modified Delphi study. Journal of Clinical Nursing, 27, 2285-2299
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