

1 **Shifts in cannabis use at the onset of the COVID-19 pandemic among Global Drug**
2 **Survey respondents from 13 countries**

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9 **ABSTRACT**

10

11 **Background:** The COVID-19 pandemic is hypothesized to have impacted cannabis access and
12 usage worldwide. This study describes changes in cannabis use and related impacts following
13 COVID-19-related restrictions among an international sample of people who use drugs.

14 **Methods:** Using data from the Global Drug Survey COVID-19 Special Edition, we identified
15 20,417 respondents from 13 countries who reported whether the number of THC-containing
16 cannabis usage days changed compared to before COVID-19 restrictions. Using a multinomial
17 multivariable logistic regression we investigated the impact of changes in cannabis use on
18 respondents' mental health, physical health, relationships, finances, work/study performance,
19 and cannabis-related pleasure/enjoyment.

20 **Results:** Similar proportions of respondents reported that their cannabis use had stayed the
21 same (38.2%) or increased (38.3%) compared to February 2020, while 21.9% of respondents
22 reported a decrease. The most common reason for increased use was having more time
23 (68.4%), while decreased use was associated with having less contact with people they use
24 cannabis with (58.4%). The likelihood of reporting worse mental and physical health, finances,
25 and work/study performance was highest among those who reported increased cannabis use.

26 **Conclusions:** These findings highlight the need for policy to address the improved provision of
27 mental health and other support for people who frequently use cannabis.

28

29 **Keywords:** Cannabis; COVID-19; Mental Health; Surveys and Questionnaires

30

31 **1. INTRODUCTION**

32 The COVID-19 outbreak, declared a pandemic by the World Health Organization on 12
33 March 2020 (World Health Organization, 2020), is hypothesized to have had a widespread
34 impact on drug distribution, access and usage worldwide (Barratt & Aldridge, 2020; UNODC,
35 2021).. For example, the United Nations Office of Drugs and Crime (UNODC) suggested that
36 the COVID-19 pandemic resulted in increased demand for cannabis, evidenced by continued
37 large-scale seizures of cannabis in the Middle East and North Africa in 2020 and 2021
38 (UNODC, 2020, 2021). Overall, global cannabis use has increased among all age groups over
39 recent years (UNODC, 2020); while some research suggests that this is due to its recent
40 decriminalization or legalization in some countries (Campeny et al., 2020; Gali et al., 2021;
41 Parker & Anthony, 2018; UNODC, 2020), other studies suggest that this is due to decreasing
42 perceptions that cannabis is harmful (Cohen et al., 2019; Gali et al., 2021; Parker & Anthony,
43 2018).

44 A notable body of research has explored the impacts of cannabis use on individuals’
45 physical and mental health (e.g., Hall, 2015; World Health Organization, 2016). The majority
46 of studies reporting physical or mental health harms from THC-containing cannabis use
47 describe harms from frequent (i.e., daily) and/or long-term use (Campeny et al., 2020; Hall,
48 2015; World Health Organization, 2016) and the causal directions of associations largely
49 remain unclear (Hall, 2015; Horwood et al., 2012; Moore et al., 2007). Physical health harms
50 associated with cannabis use commonly arise from mixing cannabis with tobacco (Hall, 2015)
51 and can include chronic bronchitis, cardiovascular disease, and strokes, but authors note a lack
52 of well-designed epidemiological studies investigating the extent of these associations (Hall,
53 2015; World Health Organization, 2016). In terms of the impact of cannabis use on mental
54 health, there is some evidence of increased risk of experiencing schizophrenia or other
55 psychotic disorders (Cohen et al., 2019; Hall, 2015; Hall & Degenhardt, 2009; Moore et al.,

56 2007; World Health Organization, 2016) and bipolar disorder (Agrawal et al., 2011; Henquet et
57 al., 2006) among people who use cannabis regularly. Other studies have found modest to weak
58 associations between cannabis use and depressive and/or affective disorders (Horwood et al.,
59 2012; Moore et al., 2007). There is also some limited evidence suggesting that cannabis use
60 may be associated with relationship conflict (Cerda et al., 2016; Haydon & Salvatore, 2022),
61 financial difficulties (Brook et al., 2013; Cerda et al., 2016), or reduced work or study
62 performance (Brook et al., 2013; Cerda et al., 2016), but these research areas are relatively
63 unexplored, and causal directions of these associations remain unknown. There is also
64 increasing global recognition of medical and therapeutic benefits associated with cannabis use
65 (e.g., reduced pain, anxiety, and inflammation, and improved sleep (Bilbao & Spanagel, 2022;
66 Vickery & Finch, 2020)), with a growing number of countries now allowing the use of
67 cannabis for medical purposes in recognition of these benefits (UNODC, 2021).. Some
68 individuals also report using cannabis simply because they derive pleasure or enjoyment from
69 doing so (Lee et al., 2007; Reilly et al., 1998). As such, when investigating impacts of cannabis
70 use, there is value in exploring the extent to which people obtain benefit from enjoying their
71 cannabis use too.

72 There is a growing body of international research reporting mixed findings regarding
73 changes in THC-containing cannabis use patterns following the COVID-19 pandemic (Chong
74 et al., 2021; Pereira et al., 2022). A 2021 scoping review on cannabis use during the COVID-
75 19 pandemic by Chong and colleagues (2021) identified 33 studies reporting changes in
76 cannabis use before and during the pandemic. While there was considerable heterogeneity in
77 the studies' designs, populations and timeframe, most studies reported either stable cannabis
78 use or increased use since the pandemic began (Chong et al., 2021). For example, a number of
79 studies reported no significant changes in cannabis use frequency compared to before the
80 COVID-19 outbreak, including cross-sectional online surveys conducted in 21 European

81 countries (Manthey et al., 2021), Belgium (Vanderbruggen et al., 2020), Germany (Werse &
82 Kamphausen, 2021), and France (Brissot et al., 2020), and a repeated measures study from the
83 USA (Graupensperger et al., 2021). Other studies have reported increased frequency of
84 cannabis use since the pandemic began, including studies of Australians who reported recent
85 cannabis use (Sutherland et al., 2020), regularly use illicit stimulants (Peacock et al., 2020), or
86 who were detained by police (Doherty et al., 2021), and a sample of survey respondents from
87 the Netherlands who reported increasing their frequency of use but not overall amount
88 (Benschop et al., 2021). A nationally-representative study from the USA noted that cannabis
89 use was particularly high at the beginning of April and May 2020, when the pandemic first
90 broke out (Brenneke et al., 2022).

91 A number of studies have also explored the reasons behind changes in cannabis use
92 during the pandemic (Chong et al., 2021; Peacock et al., 2020; Vanderbruggen et al., 2020).
93 For example, the scoping review by Chong et al (2021) identified 37 studies that described the
94 impacts of psychological stressors, changes in cannabis's accessibility, cannabis use
95 promotion, and decreased treatment access on changes in cannabis use during COVID-19.
96 Other studies from California (Fedorova et al., 2022), Belgium (Vanderbruggen et al., 2020)
97 and Australia (Peacock et al., 2020) described increased cannabis use during COVID-19
98 restrictions due to boredom, while a cross-sectional study of 70 Canadian young adults found
99 that respondents who experienced self-isolation during the COVID-19 pandemic used 20%
100 more cannabis than those who did not (Bartel et al., 2020). The scoping review (Chong et al.,
101 2021) also identified 14 studies investigating adverse clinical and psychiatric outcomes of
102 cannabis use during the pandemic. While most of these described increased susceptibility of
103 people who used cannabis to COVID-19 infection (Chong et al., 2021), two studies noted
104 adverse health outcomes for people who used cannabis heavily (increased severity of COVID-
105 19 symptoms and hospitalization) (Hatoum et al., 2021; Volkow, 2020), two described

106 increased likelihood of poor mental health among people who used cannabis during this period
107 (Borgonhi et al., 2021; Lázaro-Pérez et al., 2020), and one described positive impacts of
108 cannabis use on mental health during this time, with cannabis providing relief from COVID-
109 19-related stress and anxiety (O'Sullivan et al., 2021).

110 Our study builds on this emerging evidence through a unique and targeted exploration
111 of changes in cannabis use following COVID-19 restrictions among a relatively large
112 international sample of people who use drugs. Secondary aims of this study include
113 investigating the associations of these changes in cannabis use with respondents' perceived
114 impacts of these changes on their mental health, physical health, relationships, finance,
115 work/study performance, and cannabis-related pleasure/enjoyment, and perceived reasons for
116 these changes.

117 **2. METHODS**

118 *2.1. Sample*

119 This study uses data from the Global Drug Survey (GDS) – COVID-19 Special Edition.
120 The GDS is an annual, anonymous, cross-sectional web survey conducted in collaboration with
121 worldwide media partners. Details about the GDS's methodology, including survey design,
122 recruitment and representativeness have been previously described (Barratt et al., 2017). In
123 addition to the annual survey at the end of each year, GDS developed a Special Edition
124 COVID-19 survey, which ran for seven weeks between 3 May and 21 June 2020, to offer
125 insights into the impact of COVID-19 on respondents' use of alcohol and other drugs, mental
126 health and relationships. The GDS COVID-19 survey was available in ten languages: Danish,
127 Dutch, English, Finnish, French, German, Hungarian, Italian, Portuguese, and Spanish. The
128 study received ethics approval from [REDACTED FOR BLIND PEER REVIEW]
129 (11671/001). All participants provided informed consent before survey commencement. From
130 an initial sample of 59,969 respondents who completed the survey, we restricted our sample to

131 respondents from countries with 500 or more respondents (n=56,927), those who reported
132 THC-containing cannabis use in the past year (n=23,584) and those who provided an answer to
133 the question about changes in the number of THC-containing cannabis usage days since
134 COVID-19 restrictions commenced (n=20,417).

135 *2.2.Measures*

136 Relevant survey questions and response options are listed in Supplementary Table 1.
137 Socio-demographic variables included gender (cis woman/ cis man/ trans woman/ trans man/
138 non-binary, with trans gender calculated by comparing gender assigned at birth to self-reported
139 gender identity (Australian Bureau of Statistics, 2021)), age, ethnicity, country of residence,
140 residential location (city/urban, regional or remote), employment status (with those who
141 reported full-time and casual/part-time employment combined into the ‘employed’ group).
142 Lifetime diagnosis of mental health and/or development conditions was calculated by
143 combining participants who indicated ever being diagnosed with at least one of the mental
144 health and/or development conditions listed in Supplementary Table 1. Those who indicated
145 cannabis use in the past 12 months were asked to indicate the number of days of cannabis use
146 in the past 30 days and whether the number of THC-containing cannabis usage days in a
147 typical week had changed when compared to February 2020 (i.e., before the global
148 implementation of COVID-19 restrictions in March 2020), with the following response
149 options: increased a lot; increased a little; stayed the same; decreased a little; decreased a lot;
150 and unsure/ don’t know. Respondents who reported an increase or decrease in their cannabis
151 use compared to February 2020 were then asked to describe the impact of changed cannabis
152 use on six measures (described hereafter as the six impact measures): mental health, physical
153 health, relationships, finances, work/study performance, and cannabis-related
154 pleasure/enjoyment (with four response options: worse; stayed the same; better; not
155 applicable). The six impact measures were selected by the authorship team who developed the

156 GDS COVID-19 survey (AW, MB, JF, ED) based on domains recognized as influencing or
157 being influenced by drug use (Daley, 2013). Respondents who reported ‘not applicable’ to any
158 of the six impact measures were excluded from analyses related to that impact measure. These
159 respondents were then asked to select reasons for their increase or decrease from a provided list
160 (see Supplementary Table 1), with multiple response options allowed.

161 2.3. Data analysis

162 First, we calculated descriptive statistics to compare socio-demographic characteristics
163 and cannabis use patterns among the total sample and those who reported that their cannabis
164 use had increased a lot, increased a little, stayed the same, decreased a little, or decreased a lot
165 when compared to February 2020. We then used descriptive statistics to compare changes in
166 cannabis use according to respondents’ home countries, to compare those who reported an
167 increase or decrease in cannabis use in terms of the six impact measures, and for the perceived
168 reasons for changes in cannabis use.

169 Finally, we conducted a multinomial multivariable logistic regression to investigate
170 associations between changes in cannabis use and the six impact measures, with cannabis use
171 ‘decreased a lot’ as the reference category. Multinomial logistic regression was chosen over
172 ordinal logistic regression as the authors considered ‘better’, ‘stayed the same’ and ‘worse’ to
173 be qualitative descriptors, and chose to err on the side of caution with respects to violating the
174 proportional odds assumption by using ordinal logistic regression. As our study aimed to
175 specifically explore the associations of *changing* cannabis behaviors during initial COVID-19
176 restrictions, participants who self-reported that their cannabis use ‘stayed the same’ (n=7,806)
177 or who answered “unsure/don’t know” (n=309) to the question about changes in cannabis use
178 were not shown the question about the six impact measures as they cannabis use either did not
179 change or any change was unknown, and were excluded from multinomial logistic regression
180 analyses. The predicted probabilities from the models were calculated using Stata’s margin

181 command (results shown in Supplementary Table 2), and then plotted for each of the six
182 impact measures to illustrate the association of changing cannabis use on the six impact
183 measures. We clustered by country (to account for any unobserved within country correlation
184 (StataCorp, 2021)) and controlled for the confounding effects of gender and age in the models
185 (modelling age as a non-linear quadratic term with estimates for both age and age²), and also
186 included gender and age as interaction variables based on previous research showing that
187 person-level characteristics can account for variance in substance use measures (Barratt et al.,
188 2017). We considered a p value of <0.05 statistically significant and applied a Bonferroni
189 correction (Neyman & Pearson, 1928). A sensitivity analysis review was undertaken
190 comparing the full model (Supplementary Table 2A and 2B) and a ‘best-fit’ reduced model
191 (Supplementary Table 3A and 3B). The estimates from the reduced model are not dissimilar to
192 the full model so for consistency we present in Figure 3 the results of the full model. All
193 analyses were conducted using Stata v16 (StataCorp, 2019).

194 **3. RESULTS**

195 A total of 20,417 respondents were included in the final sample. Table 1 shows the
196 sample’s socio-demographic characteristics; the majority described themselves as cis-male
197 (61.4%), white (76.1%), employed (67.5%), and living in a city/urban area (68.1%). The
198 median age of the sample was 27 years (interquartile range (IQR) 22-35 years). Respondents’
199 most common country of residence was Germany (38.2%). Nearly a third of respondents
200 (29.5%) reported a lifetime history of a mental health and/or developmental condition.
201 Respondents most frequently described using cannabis alone at home (42.3%) in the past 30
202 days, and approximately a quarter of respondents reported using cannabis alone a little or a lot
203 more often (25.2% combined) compared to before COVID-19 restrictions, while 9% of
204 respondents reported using it alone a little or a lot less often.

205 Respondents most commonly reported that their cannabis use had increased in a typical
206 week compared to February 2020 (38.3%; comprised of 22.6% who reported it had increased a
207 little, and 15.7% who reported it had increased a lot; see Table 1). A near identical proportion
208 of respondents reported their cannabis use stayed the same (38.2%), while 21.9% of
209 respondents reported a decrease in their cannabis use since COVID-19 restrictions commenced
210 (including 8.2% who reported that it had decreased a little and 13.7% who reported it had
211 decreased a lot). Approximately 1.5% of the sample answered “don’t know/unsure” about
212 whether their cannabis use had changed when compared to February 2020.

213 Respondents reported using cannabis on a median of seven days (IQR 1-26 days) in the
214 previous 30 days. This ranged from a median of 20 days (IQR 10-30) among those who
215 reported their cannabis use had increased a lot since February 2020, to a median of 0 days
216 (IQR 0-3) among those who reported it had decreased a lot, suggesting an association between
217 overall days of use and changes in cannabis use.

218 Among respondents who reported an increase or decrease in cannabis use, respondents
219 most commonly reported that their mental health, physical health, relationships, finances,
220 work/study performance and cannabis-related pleasure enjoyment stayed the same compared to
221 February 2020 (Table 2). Figure 1 shows that the most commonly reported reasons for
222 increased cannabis use during restrictions included having more time to use cannabis (68.4%),
223 and/or boredom (66.6%; Figure 1A). The most common reasons for decreases in cannabis use
224 included less contact with people who they use it with (58.4%), and fewer occasions for usage
225 (48.8%; Figure 1B).

226 Figure 2 shows that respondents from all countries were most likely to report that their
227 cannabis use had stayed the same compared to February 2020, except for Brazil, where
228 respondents were most likely to report their cannabis use had decreased a lot. Comparing all
229 countries, respondents from Brazil were most likely to report decreasing their cannabis use a

230 lot (33.5%) and decreasing it a little (9.5%), tied with respondents from the United Kingdom
231 for the latter. Respondents from Switzerland were most likely to report that their cannabis use
232 stayed the same (45.0%). Alternatively, those from Denmark were most likely to report their
233 cannabis use had increased a little (27.6%; followed closely by those from the United States at
234 27.4%), while respondents from Australia were most likely to report that their cannabis use had
235 increased a lot (25.0%).

236 Figure 3 shows the predicted probabilities (adjusted for gender and age) of respondents
237 who self-reported changes in the six impact measures following changes in their cannabis use.
238 Supplementary Table 2 shows the relative risk ratios used to produce Figure 3. First,
239 respondents most commonly reported that their mental health, physical health, relationships,
240 finances, work/study performance, and cannabis-related pleasure stayed the same. Graphs A
241 (mental health) and C (relationships) in Figure 3 show similar trends; respondents were more
242 likely to report that their mental health and relationships improved, irrespective of whether
243 they reported that their cannabis use increased (a lot or a little) or decreased (a lot or a little).
244 Furthermore, those who reported increasing their cannabis use a lot were equally as likely to
245 report that their mental health got better or got worse. However, the predicted probability of
246 self-reporting worse mental health was highest among those who reported increasing their
247 cannabis use a little, followed by those who increased a lot. Graphs B (physical health), D
248 (finances), and E (work/study performance) show similar trends; as self-reported cannabis use
249 increased, we found an increase in the predicted probability of respondents' describing their
250 physical health, finances and work/study performance worsening, with those who reported that
251 their cannabis use had increased a lot being most likely to report that their physical health,
252 finances, and work/study performance worsened, and least likely to report it improved after
253 COVID-19 restrictions. Finally, graph F shows a positive association in the predicted

254 probability, with respondents more likely to report that cannabis-related pleasure improved as
255 cannabis use increased.

256 4. DISCUSSION

257 This study describes self-reported changes in cannabis use following the global
258 introduction of COVID-19 restrictions among an international sample of people who used
259 cannabis in the past year. Noting that our data derives from a cross-sectional survey
260 incorporating a retrospective exploration of respondents' self-reported changes in cannabis use
261 and outcomes, our study explores the associations of respondents' self-described changes in
262 cannabis use since the COVID-19 pandemic commenced with the perceived impacts of their
263 changed cannabis use on their mental health, physical health, relationships, finances,
264 work/study performance, and cannabis-related pleasure outcomes. These findings provide an
265 understanding of the short-term impact of initial COVID-19 restrictions, with international
266 variations in these trends reflecting the impact of COVID-19 on environmental-level factors
267 (e.g., lockdowns, border closures and travel restrictions) that have influenced global drug
268 supply and access (EMCDDA, 2020), and individual-level factors (e.g. loneliness, self-
269 isolation, boredom (Bartel et al., 2020; Fedorova et al., 2022; Peacock et al., 2020;
270 Vanderbruggen et al., 2020)) recognized as influencing drug use (Ingram et al., 2020).

271 Respondents most commonly reported no changes in their cannabis use following
272 COVID-19 restrictions, reflecting findings from other international studies (Chong et al., 2021;
273 Graupensperger et al., 2021; Vanderbruggen et al., 2020; Werse & Kamphausen, 2021).
274 Similar numbers of respondents reported increasing their cannabis use a lot (15.7%) or
275 decreasing it a lot (13.7%) since COVID-19 restrictions commenced, echoing findings from
276 other studies, such as a study of 36,538 adults from 21 European countries (Manthey et al.,
277 2021). Respondents most commonly reported increasing their cannabis use because they had
278 more time to use it or were bored, directly aligning with findings from studies that have

279 explored reasons for changes in cannabis use following the outbreak of COVID-19 (Chong et
280 al., 2021; Fedorova et al., 2022; Peacock et al., 2020; Vanderbruggen et al., 2020). Those who
281 described decreasing their cannabis use most commonly ascribed this to having less contact
282 with people they use it with, reflecting the social nature of cannabis use for many people
283 (Buckner et al., 2012; Johnson et al., 2019). As the body of research exploring changes in
284 substance use following the outbreak of COVID-19 continues to expand (Chong et al., 2021), it
285 will be valuable for future research to investigate the true extent of COVID-19 restrictions on
286 peoples' choice to use and/or ability to access cannabis, and the environmental factors and
287 individual motives that drive these changing patterns of substance use.

288 Australian respondents were most likely to report increasing their cannabis a lot,
289 consistent with findings from other Australian-based studies (Doherty et al., 2021; Peacock et
290 al., 2020; Sutherland et al., 2020), including from the National Wastewater Drug Monitoring
291 Program (NWDMP), which reported a record high of cannabis consumption in Australia's
292 capital cities in June 2020 (Australian Criminal Intelligence Commission, 2020). While we did
293 not analyze country-specific reasons for changes in use, and these are non-representative
294 percentages based on varying sample sizes, NWDMP authors ascribe this to the largely local
295 nature of Australian cannabis cultivation and supply (Australian Criminal Intelligence
296 Commission, 2020). On the other hand, respondents from Brazil were most likely to report
297 decreasing their cannabis use a lot. A cross-sectional study of drug use during COVID-19
298 restrictions among 2,435 Brazilian people reported no overall change in cannabis use, yet
299 significantly decreased cannabis use among participants who reported engaging in rigorous or
300 very rigorous social distancing (Nin et al., 2022). As such, although the reason for our finding
301 remains unknown, it is possible that Brazilian respondents were more likely to reduce their
302 cannabis use as a direct result of COVID-19 restrictions such as social distancing than those

303 from other countries, especially within the context of high numbers of COVID-19 cases and
304 deaths in Brazil compared to other countries (Guerin, 2021).

305 Interestingly, we found that those who reported increasing their cannabis use a lot were
306 equally as likely to report that their mental health improved or worsened, but also that these
307 respondents' risk of reporting worse mental health following COVID-19 restrictions was
308 highest. As with other studies (Hall, 2015; Horwood et al., 2012; Moore et al., 2007), the
309 causal direction of these associations remains unknown, and it is unknown whether other
310 factors (related or unrelated to COVID-19 restrictions) mediated these associations. However,
311 irrespective of the direction of these associations, previous studies have found associations
312 between self-isolation and increased cannabis use (Bartel et al., 2020; Fedorova et al., 2022),
313 COVID-19 restrictions and poor mental health (Borgonhi et al., 2021; Javanbakht et al., 2022;
314 Lázaro-Pérez et al., 2020; Sutherland et al., 2020), and using cannabis to cope with anxiety
315 (Javanbakht et al., 2022; O'Sullivan et al., 2021; Temple et al., 2014). We also found that
316 respondents who reported increased cannabis use since the COVID-19 pandemic commenced
317 were more likely to report worsened physical health, finances and work/study performance.
318 This finding aligns with those of previous studies reporting financial difficulties, workplace
319 problems, and relationship conflict among people reporting frequent cannabis use (Brook et al.,
320 2013; Cerda et al., 2016; Haydon & Salvatore, 2022). For example, a longitudinal cohort study
321 of 1,037 New Zealanders found that participants reporting persistent cannabis dependence
322 were more likely to report financial difficulties, workplace problems, and relationship conflict
323 (Cerda et al., 2016). However, as is the case for our other findings, the causal direction of these
324 associations, the impacts of other factors on these associations are unknown, and it is likely
325 that the COVID-19 pandemic and associated restrictions impacted respondents' physical
326 health, finances and work/study performance independent of their cannabis use. We also found
327 that respondents were more likely to report that cannabis-related pleasure improved as

328 cannabis use increased. Although previous studies have reported enjoyment as a common
329 reason for cannabis use (Lee et al., 2007; Reilly et al., 1998), cannabis use for enjoyment or
330 pleasure purposes remains a relatively unexplored area of research, and a greater understanding
331 of this benefit of cannabis use may be valuable to supplement knowledge on cannabis's known
332 medical and therapeutic benefits (Bilbao & Spanagel, 2022; Vickery & Finch, 2020).

333 As the COVID-19 pandemic continues, there will be opportunities for further research
334 to explore these associations in more detail, especially the extent to which cannabis use may or
335 may not impact the physical and mental health, relationships, finances, work/study
336 performance and cannabis-related pleasure among people who use it. In particular, these
337 findings highlight a clear a need for the ongoing and improved provision of evidence-based
338 mental health support throughout the COVID-19 pandemic, particularly targeted at those with
339 a history of mental illness and/or who may engage in potentially risky drug use exacerbated by
340 COVID-19 and associated restrictions. Furthermore, initiatives that encourage people to go
341 outdoors and spend time in nature or engage in other mindful activities that center around self-
342 care and creating community and purpose may decrease boredom and potentially prevent risky
343 levels of cannabis use.

344 **4.1. Strengths and Limitations**

345 Our study's relatively large sample size (n=20,416), with respondents recruited from 13
346 countries, allows for a novel international comparison of changes in cannabis use following
347 COVID-19 restrictions. Our findings are also subject to some limitations. First, the GDS is a
348 cross-sectional survey that recruits a self-selected convenience sample of people who use drugs
349 and have an internet connection, limiting our findings' generalizability. The non-compulsory
350 nature of many GDS questions also resulted in missing data across most variables. Third, as the
351 survey only ran between 3 May and 21 June 2020, it is likely that several respondents'
352 cannabis use frequency has subsequently changed again as COVID-19 restrictions have largely

353 since eased internationally. The accuracy of the data may have also been negatively affected by
354 the nature of self-report, as some respondents' answers may be incorrect or subject to recall
355 bias. We also did not measure respondents' changes in the amount of cannabis use, only self-
356 reported frequency of use, meaning that some respondents who reported an increase in the
357 number of days of cannabis use may have actually used less cannabis overall, and vice versa.
358 The reported associations between changes in cannabis use and the six outcome measures may
359 have also been affected by concurrent use of other substances, which was not accounted for in
360 our analyses. Next, it is possible that some respondents who reported using more or less
361 cannabis may have done so for reasons unrelated to COVID-19. We also did not account for
362 differing patterns of use in countries or jurisdictions where adult cannabis use is legal. For
363 example, in some places, such as California in the USA, cannabis dispensaries were considered
364 essential businesses and remained open throughout COVID-19 restrictions (Roberts, 2020).
365 Finally, we also did not apply any advanced modelling approaches to account for the large
366 variation in respondent numbers from different countries (such as weighted regression to
367 account for heteroskedasticity due to vary sample sizes across countries). Future research may
368 benefit from accounting for concurrent substance use and the jurisdictional legal status of
369 cannabis in more sophisticated modelling (including accounting for varying cluster sizes).

370 **5. CONCLUSIONS**

371 Among an international sample of people who used cannabis in the past year, the
372 proportion of respondents who reported no change (38.2%) or an increase (38.3%) in the
373 frequency of cannabis use following the outbreak of the COVID-19 pandemic were
374 comparable. Respondents were most likely to report that the perceived impacts of their
375 changed cannabis use on their mental health, physical health, relationships, finances,
376 work/study performance, and cannabis-related pleasure outcomes stayed the same as before
377 February 2020, but risk of reporting worse mental health following COVID-19 restrictions was

378 highest among those who reported increasing their cannabis use. Furthermore, as respondents'
379 reported cannabis use increased, we found an increased likelihood of respondents reporting that
380 their physical health, finances and work/study performance worsened. This study's unique
381 exploration of the associations of self-reported changes in cannabis use on individuals'
382 perceived mental health, physical health, relationships, finances, work/study performance, and
383 cannabis-related pleasure outcomes adds to a growing body of research describing the impacts
384 of the COVID-19 pandemic on cannabis use, and highlight the need for increased and ongoing
385 evidence-based psychological support targeted at those who may engage in risky drug use
386 exacerbated by COVID-19 and associated restrictions.

387

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Table 1. Socio-demographic characteristics for the sample of people who reported in the number of THC-containing cannabis usage days when compared to February 2020 (pre-COVID restrictions)

Characteristic	Number (%) [missing]					
	Full sample (n=20,417) ^a	Cannabis use increased a lot (n=3,211)	Cannabis use increased a little (n=4,613)	Cannabis use decreased a little (n=1,680)	Cannabis use decreased a lot (n=2,797)	Cannabis use stayed the same (n=7,807)
Gender						
Cis woman	7,478 (36.7)	1,207 (37.6)	1,751 (38.0)	582 (34.6)	1,082 (38.7)	2,759 (35.3)
Cis man	12,533 (61.4)	1,942 (60.5)	2,774 (60.1)	1,063 (63.3)	1,660 (59.4)	4,897 (62.7)
Trans woman	47 (0.2)	4 (0.1)	11 (0.2)	5 (0.3)	5 (0.2)	21 (0.3)
Trans man	58 (0.3)	11 (0.3)	8 (0.2)	9 (0.5)	9 (0.3)	20 (0.3)
Non-binary	292 (1.4)	47 (1.5)	69 (1.5)	21 (1.3)	41 (1.4)	110 (1.4)
Age: Median (Interquartile Range [IQR])	27 (22-35)	26 (21-32)	27 (22-34)	26 (22-34)	25 (21-32)	29 (23-37)
Ethnicity ^b						
White	15,545 (76.1)	2,371 (73.8)	3,658 (79.3)	1,275 (76.0)	1,981 (68.6)	6,094 (78.1)
Mixed	840 (4.1)	153 (4.8)	179 (3.9)	73 (4.3)	145 (5.2)	276 (3.6)
Hispanic/ Latino	237 (1.2)	33 (1.0)	48 (1.0)	15 (0.9)	71 (2.5)	68 (0.9)
Asian	161 (0.8)	36 (1.1)	34 (0.7)	12 (0.7)	27 (1.0)	49 (0.6)
Black/ African American	137 (0.7)	25 (0.8)	22 (0.5)	12 (0.7)	37 (1.3)	41 (0.5)
Aboriginal/Māori	63 (0.3)	20 (0.6)	13 (0.3)	0 (0.0)	5 (0.2)	25 (0.3)
Native American	1 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
Other	215 (1.0)	46 (1.4)	39 (0.8)	16 (1.0)	36 (1.3)	72 (0.9)
	[3,218 (15.7)]	[526 (16.4)]	[620 (13.4)]	[277 (16.5)]	[558 (19.9)]	[1,182 (15.1)]
Country of Residence						
Australia	1,007 (4.9)	252 (7.8)	232 (5.0)	64 (3.8)	101 (3.6)	340 (4.4)
Austria	494 (2.4)	72 (2.3)	123 (2.7)	41 (2.4)	65 (2.3)	186 (2.4)
Brazil	1,323 (6.5)	141 (4.4)	220 (4.8)	126 (7.6)	443 (15.8)	368 (4.7)
Denmark	315 (1.5)	65 (2.0)	87 (1.9)	23 (1.4)	26 (1.0)	105 (1.3)
France	3,040 (14.9)	498 (15.5)	580 (12.6)	260 (15.5)	536 (19.2)	1,115 (14.3)
Germany	7,792 (38.2)	1,048 (32.6)	1,850 (40.1)	669 (39.8)	869 (31.1)	3,248 (41.6)
Greece	235 (1.2)	30 (0.9)	38 (0.8)	21 (1.3)	62 (2.2)	74 (1.0)
Ireland	909 (4.5)	173 (5.4)	181 (3.9)	77 (4.6)	168 (6.0)	297 (3.8)
Netherlands	1,728 (8.5)	331 (10.3)	453 (9.8)	117 (7.0)	137 (4.9)	665 (8.5)
New Zealand	923 (4.5)	167 (5.2)	207 (4.5)	64 (3.8)	86 (3.1)	386 (4.9)
Switzerland	1,227 (6.0)	152 (4.8)	294 (6.4)	86 (5.1)	132 (4.7)	552 (7.1)
United Kingdom	950 (4.6)	195 (6.1)	218 (4.7)	90 (5.4)	132 (4.7)	297 (3.8)
United States	474 (2.3)	87 (2.7)	130 (2.8)	39 (2.3)	40 (1.4)	174 (2.2)

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Residential Location						
City / Urban area	13,908 (68.1)	2,237 (69.7)	3,191 (69.2)	1,148 (68.3)	1,852 (66.2)	5,273 (67.5)
Regional area	4,058 (19.9)	595 (18.5)	877 (19.0)	331 (19.7)	588 (21.0)	1,605 (20.6)
Remote area	1,063 (5.2)	151 (4.7)	211 (4.6)	94 (5.6)	164 (5.9)	423 (5.4)
	[1,388 (6.8)]	[228 (7.1)]	[334 (7.2)]	[107 (6.4)]	[193 (6.9)]	[506 (6.5)]
Employment status						
Employed	13,779 (67.5)	2,158 (67.2)	3,220 (69.8)	1,067 (63.5)	1,612 (57.6)	5,506 (70.5)
Unemployed	6,484 (31.8)	1,026 (32.0)	1,373 (29.8)	595 (35.4)	1,164 (41.6)	2,235 (28.6)
	[154 (0.8)]	[27 (0.8)]	[20 (0.4)]	[18 (1.1)]	[21 (0.8)]	[66 (0.9)]
Lifetime diagnoses of mental health and/or developmental condition						
Yes	6,032 (29.5)	1,032 (32.1)	1,323 (28.7)	509 (30.3)	912 (32.6)	2,189 (28.0)
No	10,465 (51.3)	1,390 (43.3)	2,340 (50.7)	889 (52.9)	1,427 (51.0)	4,259 (54.6)
	[3,920 (19.2)]	[789 (24.6)]	[950 (16.8)]	[282 (16.8)]	[458 (16.4)]	[1,359 (17.4)]
Number of days of cannabis use in the past 30 days: Median (IQR)	7 (1-26)	20 (10-30)	15 (5-29)	3 (0-15)	0 (0-3)	3 (0-30)
	[445 (2.2)]	[73 (2.3)]	[133 (2.9)]	[37 (2.2)]	[77 (2.8)]	[122 (1.56)]
Settings in which cannabis was used in last 30 days [#]						
Alone at home with no contact with others	8,634 (42.3)	1,940 (60.4)	2,577 (55.9)	606 (36.1)	549 (19.6)	2,931 (37.5)
Alone at home with others co-present (e.g., video calls)	4,041 (19.8)	988 (30.8)	1,271 (27.6)	283 (16.8)	202 (7.2)	1,289 (16.5)
With household members at home	5,996 (29.4)	1,350 (42.0)	1,893 (41.0)	362 (21.5)	288 (10.3)	2,079 (26.6)
With household members and other people co-present (e.g., video calls)	1,680 (8.2)	448 (14.0)	542 (11.7)	95 (5.7)	54 (1.9)	535 (6.9)
Music festivals	466 (2.3)	113 (3.5)	129 (2.8)	36 (2.1)	41 (1.5)	144 (1.8)
Nightclubs	352 (1.7)	91 (2.8)	94 (2.0)	25 (1.5)	28 (1.0)	108 (1.4)
House parties	2,149 (10.5)	479 (14.9)	588 (12.7)	168 (10.0)	133 (4.8)	758 (9.7)
Smaller gatherings	3,292 (16.1)	735 (22.9)	967 (21.0)	273 (16.3)	256 (9.2)	1,030 (13.2)
Underground parties/ events	466 (2.3)	126 (3.9)	115 (2.5)	31 (1.8)	36 (1.3)	152 (1.9)
Street or public places	3,592 (17.6)	834 (26.0)	1,095 (23.7)	246 (14.6)	258 (9.2)	1,131 (14.5)
	[2,468 (18.2)]	[453 (16.1)]	[639 (15.9)]	[202 (20.2)]	[229 (23.8)]	[929 (19.7)]
Using cannabis alone more or less often when compared to February 2020 [#]						
A lot less often	889 (4.4)	112 (3.5)	76 (1.6)	105 (6.3)	483 (17.3)	111 (1.4)
A little less often	939 (4.6)	76 (2.4)	121 (2.6)	313 (18.6)	114 (4.1)	260 (3.3)
About the same	4,523 (22.2)	259 (8.1)	1,023 (22.2)	293 (17.4)	111 (4.0)	2,814 (36.0)
A little more often	3,181 (15.6)	672 (20.9)	1,746 (37.8)	123 (7.3)	60 (2.1)	569 (7.3)
A lot more often	1,953 (9.6)	1,332 (41.5)	337 (7.3)	30 (1.8)	59 (2.1)	190 (2.4)
Does not use cannabis alone	1,530 (7.5)	244 (7.6)	483 (10.5)	107 (6.4)	95 (3.4)	575 (7.4)
Unsure/Don't know	219 (1.1)	41 (1.3)	71 (1.5)	11 (0.6)	15 (0.5)	69 (0.9)
	[7,183 (35.2)]	[475 (14.8)]	[704 (15.3)]	[698 (41.6)]	[1,860 (66.5)]	[3,219 (41.2)]

IQR=interquartile range; ^a The full sample includes 309 participants who answered “don’t know/ unsure” for the question asking whether their number of cannabis usage days had changed compared to before COVID-19 restrictions; ^b Regulations in France prevented questioning around ethnicity, leading to higher rates of missing data on this variable; [#]Multiple responses permitted

Table 2. Cannabis use patterns and impacts for the full sample and according to change in THC-containing cannabis use

Characteristic	Number (%) [missing]			
	Cannabis use increased a lot (n = 3,211)	Cannabis use increased a little (n = 4,613)	Cannabis use decreased a little (n = 1,680)	Cannabis use decreased a lot (n = 2,797)
Impact of changed cannabis use on mental health (n = 12,143)				
Worse	806 (25.1)	646 (14.0)	156 (9.3)	341 (12.2)
Stayed the same	1,574 (49.0)	2,974 (64.5)	1,192 (70.9)	1,611 (57.6)
Better	740 (23.1)	865 (18.7)	248 (14.8)	650 (23.2)
Not applicable	55 (1.7)	81 (1.8)	59 (3.5)	145 (5.2)
	[36 (1.1)]	[47 (1.0)]	[25 (1.5)]	[50 (1.8)]
Impact of changed cannabis use on physical health (n = 12,101)				
Worse	959 (29.9)	742 (16.1)	78 (4.7)	138 (4.9)
Stayed the same	1,864 (58.1)	3,356 (72.8)	1,296 (77.1)	1,757 (62.8)
Better	275 (8.6)	342 (7.4)	216 (12.9)	687 (24.6)
Not applicable	59 (1.8)	112 (2.4)	61 (3.6)	159 (5.7)
	[54 (1.7)]	[61 (1.3)]	[29 (1.7)]	[56 (2.0)]
Impact of changed cannabis use on relationships (n = 12,009)				
Worse	399 (12.4)	312 (6.8)	85 (5.1)	192 (6.9)
Stayed the same	2,075 (64.6)	3,426 (74.3)	1,328 (79.0)	1,944 (69.5)
Better	530 (16.5)	583 (12.6)	126 (7.5)	339 (12.1)
Not applicable	134 (4.2)	195 (4.2)	101 (6.0)	240 (8.6)
	[73 (2.3)]	[97 (2.1)]	[40 (2.4)]	[82 (2.9)]
Impact of changed cannabis use on finances (n = 11,909)				
Worse	894 (27.8)	741 (16.1)	65 (3.9)	81 (2.9)
Stayed the same	1,994 (62.1)	3,385 (73.4)	1,222 (72.7)	1,683 (60.2)
Better	116 (3.6)	182 (3.9)	248 (14.8)	710 (25.4)
Not applicable	122 (3.8)	164 (3.6)	94 (5.6)	208 (7.4)
	[85 (2.7)]	[141 (3.0)]	[51 (3.0)]	[115 (4.1)]
Impact of changed cannabis use on work/study performance (n = 11,896)				
Worse	917 (28.6)	781 (17.0)	100 (6.0)	159 (5.6)
Stayed the same	1,684 (52.4)	3,082 (66.8)	1,236 (73.6)	1,781 (63.7)
Better	218 (6.8)	274 (5.9)	153 (9.1)	416 (14.9)
Not applicable	288 (9.0)	327 (7.1)	142 (8.4)	338 (12.1)
	[104 (3.2)]	[149 (3.2)]	[49 (2.9)]	[103 (3.7)]
Impact of changed cannabis use on cannabis-related pleasure/enjoyment (n = 11,975)				
Worse	631 (19.6)	603 (13.1)	229 (13.6)	474 (16.9)
Stayed the same	1,294 (40.3)	2,596 (56.3)	1,063 (63.3)	1,478 (52.9)
Better	1,158 (36.1)	1,213 (26.3)	245 (14.6)	353 (12.6)
Not applicable	51 (1.6)	83 (1.8)	103 (6.1)	401 (14.3)
	[77 (2.4)]	[118 (2.5)]	[40 (2.4)]	[91 (3.3)]

#Multiple responses permitted

RUNNING TITLE: Shifts in cannabis use following COVID-19 restrictions

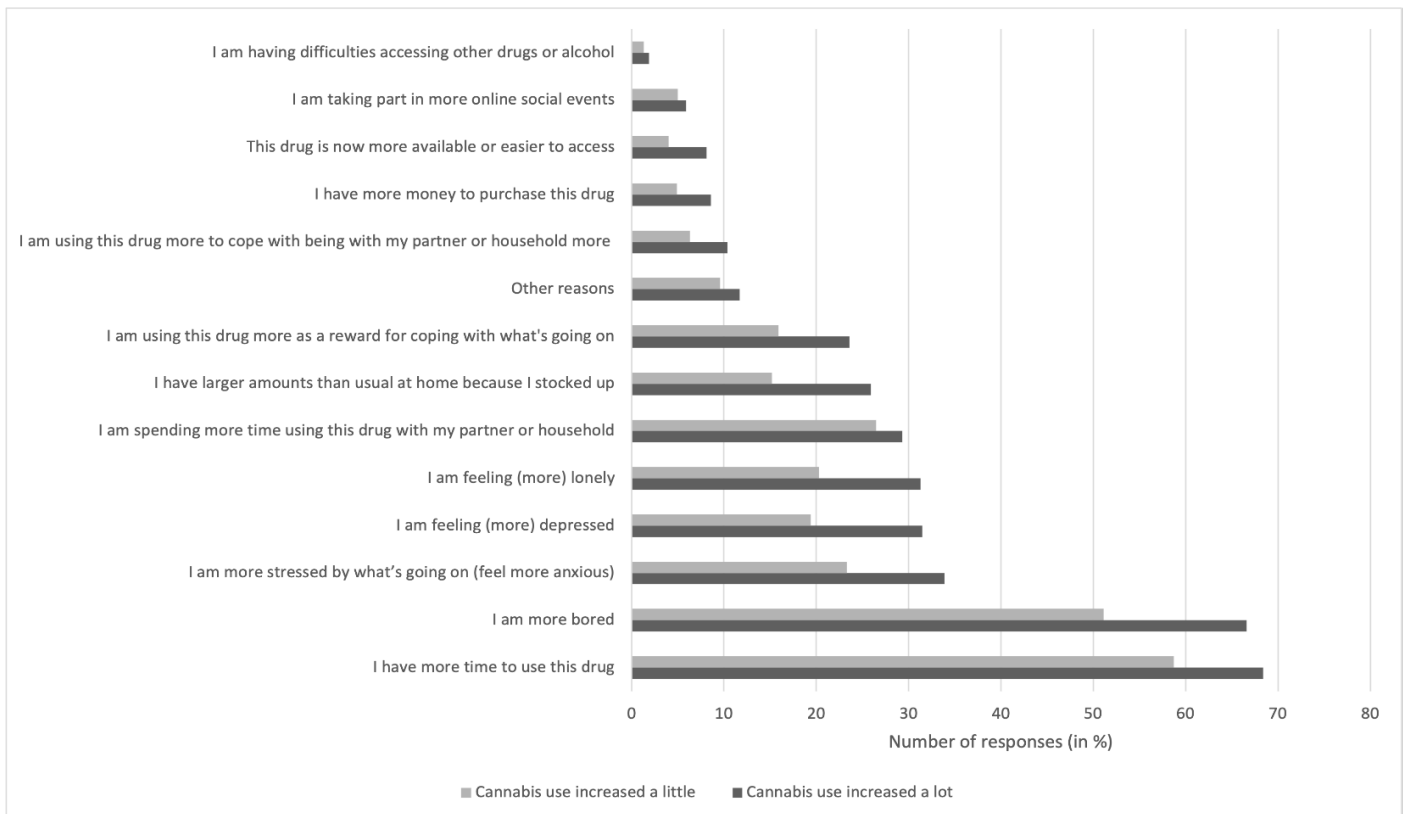


Figure 1A. Reported reasons for increased cannabis use when compared to February 2020.

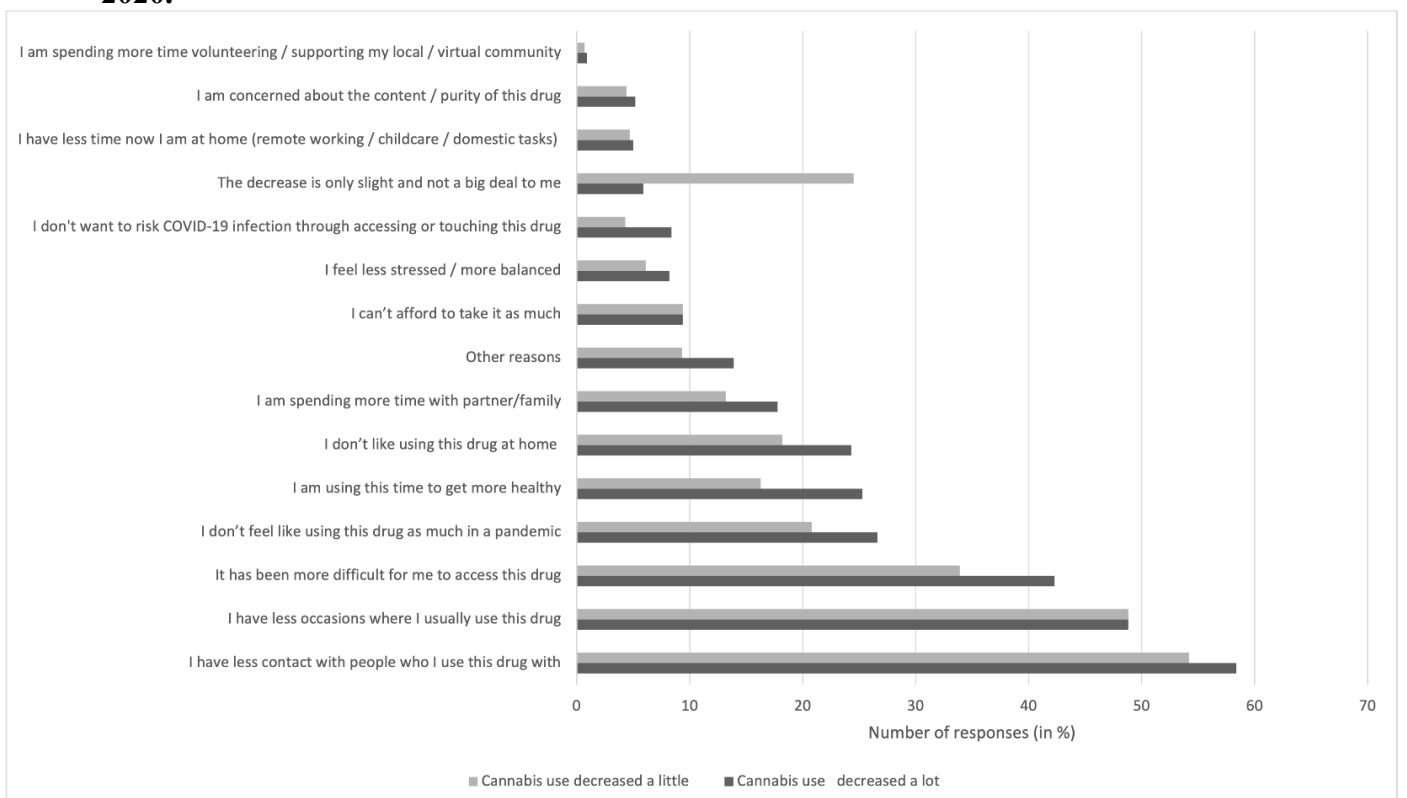


Figure 1B. Reported reasons for decreased cannabis use when compared to February 2020.

RUNNING TITLE: Shifts in cannabis use following COVID-19 restrictions

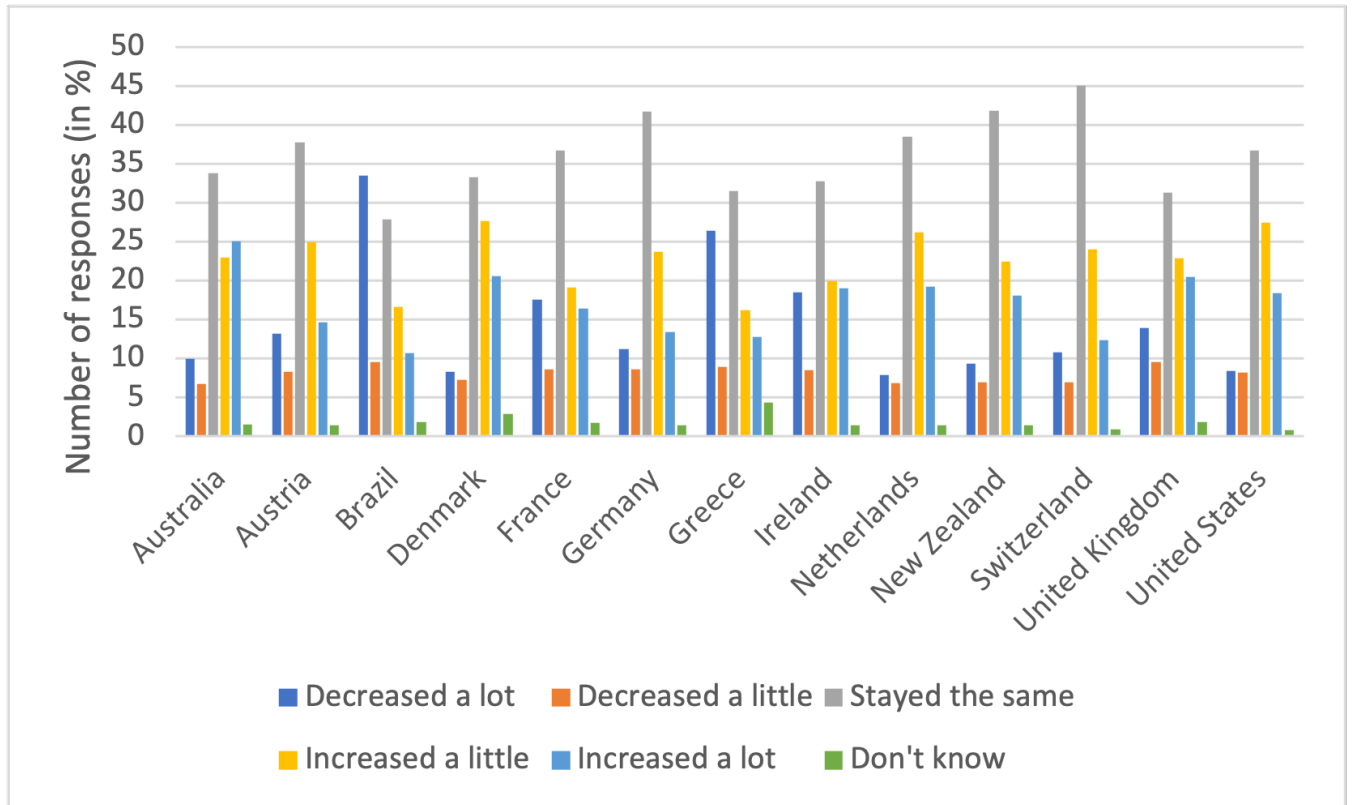
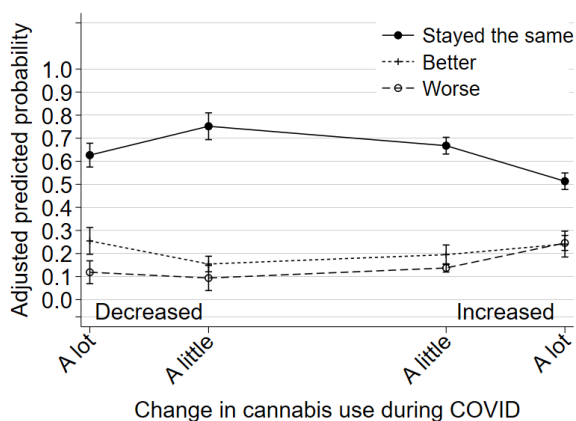


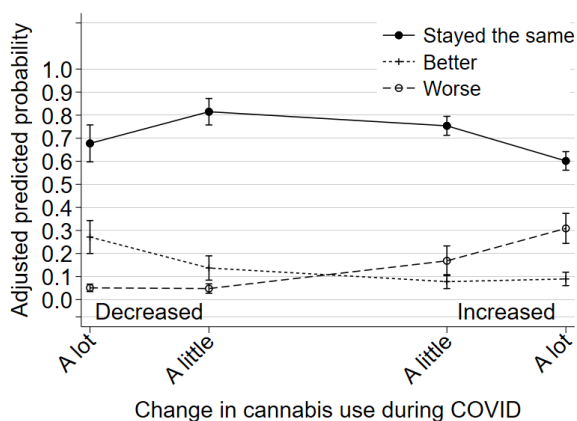
Figure 2. Changes in cannabis use compared to February 2020 by country

RUNNING TITLE: Shifts in cannabis use following COVID-19 restrictions

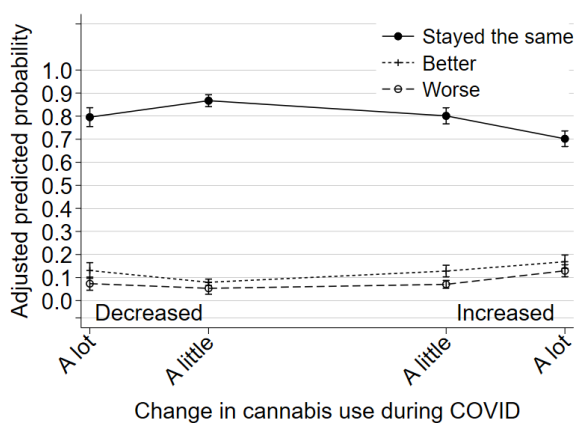
A) Mental health



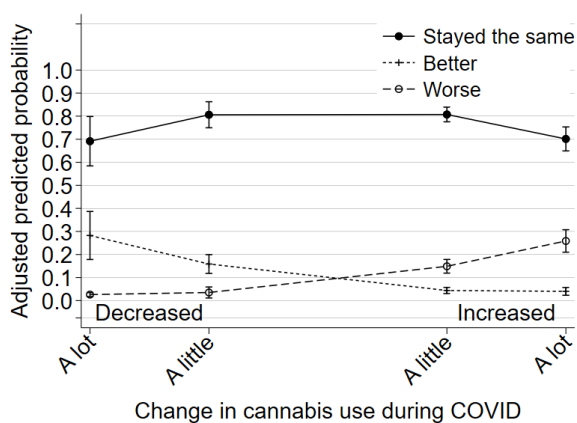
B) Physical health



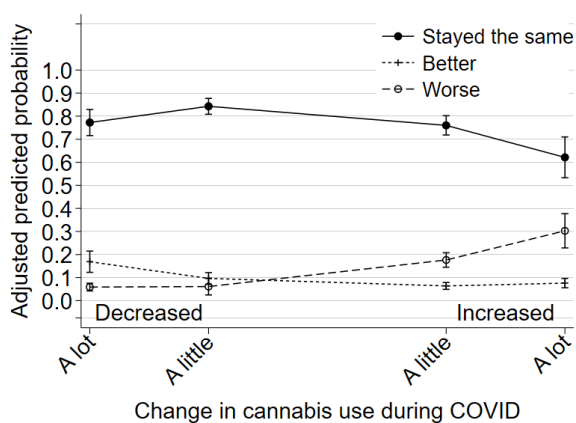
C) Relationships



D) Finances



E) Work/ study performance



F) Cannabis-related pleasure/ enjoyment

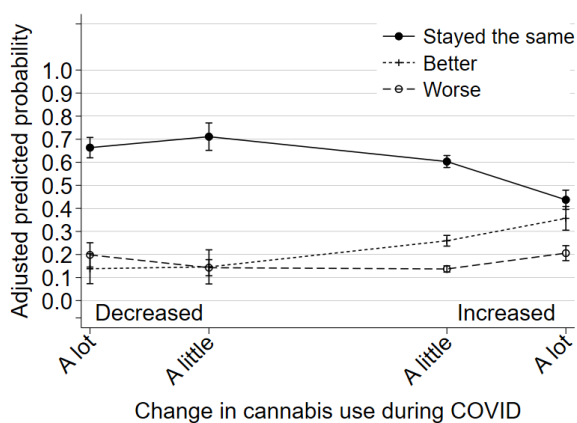


Figure 3. Predicted probabilities of the reported impacts of changes in cannabis use when compared to February 2020 (after adjusting for cisgender and age and clustering for country).