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Impact of health warning labels communicating the risk of cancer on alcohol selection:

An online experimental study

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Competing interests

The authors declare no competing interests.

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Abstract

30 **Background and Aims**

31 Evidence from tobacco research suggests that health warning labels (HWLs) depicting the
32 adverse consequences of consumption change smoking behaviours, with image-and-text (also
33 known as ‘pictorial’ or ‘graphic’) HWLs most effective. There is an absence of evidence
34 concerning the potential impact of HWLs placed on alcohol products on selection of those
35 products. This study aimed to obtain a preliminary assessment of the possible impact of (a)
36 image-and-text (b) text-only and (c) image-only HWLs on selection of alcoholic versus non-
37 alcoholic drinks.

38 **Design**

39 A between-subjects randomised experiment with a 2 (image: present *vs* absent) x 2 (text:
40 present *vs* absent) factorial design.

41 **Setting**

42 The study was conducted on the online survey platform Qualtrics.

43 **Participants**

44 Participants (n=6024) were adults over the age of 18 who consumed beer or wine regularly
45 (*i.e.*, at least once a week), recruited through a market research agency.

46 **Interventions**

47 Participants were randomised to one of four groups varying in the HWL displayed on the
48 packaging of alcoholic drinks: i. image-and-text HWL; ii. text-only HWL; iii. image-only
49 HWL; iv. no HWL. HWLs depicted bowel cancer, breast cancer and liver cancer, which were
50 each displayed twice across six alcoholic drinks. Each group viewed six alcoholic and six non-
51 alcoholic drinks and selected one drink that they would like to consume.

52 **Measurements**

53 The primary outcome was the proportion of participants selecting an alcoholic versus a non-
54 alcoholic drink.

55 **Findings**

56 Alcoholic drink selection was lower for all HWL types compared with no HWL (image-and-
57 text: 56%; image-only: 49%; text-only: 61%; no HWL: 77%), with selection lowest for
58 HWLs that included an image. Image-and-text HWLs reduced the odds of selecting an
59 alcoholic drink compared with text-only HWLs (OR = 0.80, 95% CI = 0.69, 0.92), but
60 increased the odds of selecting an alcoholic drink compared with image-only HWLs (OR =
61 1.34, 95% CI = 1.16, 1.55).

62 **Conclusions**

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63 Health warning labels communicating the increased risk of cancers associated with alcohol
64 consumption reduced selection of alcoholic versus non-alcoholic drinks in a hypothetical
65 choice task in an online setting; labels displaying images had the largest effect. Their impact
66 in laboratory and real-world field settings using physical products awaits investigation.

67 **Keywords:** health warning label, pictorial health warning label, alcohol, graphic warnings,
68 choice architecture, cancer

69 **Registration:** Open Science Framework: <https://osf.io/pr8zu/>

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Background

96 Excessive consumption of alcohol increases the risk of a range of diseases including liver
97 disease, heart disease and some cancers (1, 2). The World Health Organisation's (WHO)
98 Global Alcohol Strategy aims to achieve at least a 10% reduction in the harmful use of alcohol
99 by 2025 (3). One potential method to reduce excessive alcohol consumption is by using labels
100 on alcohol products to inform consumers of their potential harmful effects. This can be
101 considered a choice architecture intervention. Such interventions typically involve altering the
102 properties or placement of objects or products in physical micro-environments in order to
103 change behaviours, with a close temporal and spatial relationship between the exposure and
104 the behaviour (4). Within the TIPPME (Typology of Interventions in Proximal Physical Micro-
105 Environments) intervention typology (4), labelling interventions are classified as *Information*
106 interventions.

107 Worldwide, labelling requirements are diverse and are typically limited. In the UK, it is only
108 mandatory to include alcohol strength on product packaging, although labels may also provide
109 information regarding alcohol unit content, low risk drinking guidelines, pregnancy warnings
110 and the dangers of drink driving through voluntary, industry-led agreements. However, current
111 UK labelling often falls short of best practice (5) and there is evidence that current labels attract
112 minimal attention (6, 7).

113 The inclusion of additional elements may increase alcohol label effectiveness, including health
114 warnings that provide information to increase the currently low awareness of the link between
115 alcohol and cancer (8, 9). Evidence for the impact of such health warnings principally derives
116 from tobacco control. Health warning labels (HWLs) on tobacco products impact a range of
117 outcomes including cessation related behaviours such as quitting intentions and smoking
118 initiation (10-12). Mandatory tobacco labelling is currently in place in 118 countries worldwide
119 (13) with guidelines specifying large warnings - no less than 30% of the packaging - that may
120 include images alongside text statements, commonly termed 'pictorial' or 'graphic' HWLs
121 (14). There are larger effects from image-and-text HWLs compared to text-only HWLs (10,
122 12, 15), possibly due to the former eliciting greater negative emotional arousal (16). Image-
123 and-text HWLs on tobacco products provide clear evidence of a feasible and acceptable
124 population level intervention (17), reaching socially and materially deprived groups (18).
125 Recent calls for improved alcohol labelling suggest HWLs, akin to those on tobacco packaging,
126 should be implemented (19). This is, however, in the context of a near-complete absence of
127 evidence of their potential efficacy, with only a small number of relevant, though typically
128 underpowered, studies conducted to date (20-23).

129 Evidence from the few studies conducted to assess the impact of HWLs on alcoholic beverages
130 suggests that their use shows promise, but there are limited studies looking at selection or
131 consumption-related behaviours (24). Text-only HWLs that include messages warning of
132 increased cancer risk can increase motivation to reduce drinking and are accepted by consumers
133 (25), with specific messages (i.e., alcohol can increase your risk of bowel cancer), having a
134 stronger effect than general messages (i.e., alcohol increases your risk of cancer) (26, 27).
135 Image-and-text HWLs can slow consumption (21) and reduce intention to drink (22, 28) and
136 exert larger effects on quitting and consumption intentions than text-only HWLs (22).
137 However, one study suggests image-and-text and text-only HWLs are equally effective at

138 reducing speed of consumption (21). With regards to image-and-text HWLs, uncertainty also
139 remains around the types of images that may exert the greatest effect. Warnings including
140 shocking or explicit pictures are most likely to be believed and are rated as more effective than
141 those with less severe pictures (29). The former, however, may also increase reactance and
142 avoidance behaviours (28) and may be less acceptable (30). It is therefore important to assess
143 the potential efficacy of a variety of HWLs, as well as levels of reactance and avoidance, and
144 acceptability.

145 A further uncertainty concerning HWLs is whether text is necessary for images to impact upon
146 behaviour, given poor specification of the mechanisms by which HWLs are effective. Previous
147 work on the use of aversive health-related images suggests that pairing less healthy snack foods
148 with aversive images of adverse health consequences – such as heart disease - without a text
149 warning statement reduces selection of the product, an effect mediated by changes in attitudinal
150 preferences (31, 32). To our knowledge, there are no studies assessing the impact of image-
151 only HWLs on alcohol. Given this absence of evidence and an assumption that some text may
152 be needed for interpretation, we hypothesised that image-only HWLs would be less effective
153 than image-and-text and text-only HWLs. Comparing the impact of an image-and-text HWL
154 to an image-only HWL could valuably indicate the extent to which text is necessary.
155 Additionally, many frequent decisions – such as what to eat or drink - are made under
156 conditions in which individuals' cognitive resources are limited or deployed elsewhere, with
157 individuals more likely to make unhealthy choices under such conditions (33). Specific
158 nutritional labelling systems may only be effective when cognitive resource is high (34, 35). It
159 is therefore important to assess the impact of HWLs on selection when cognitive resource is
160 limited. One commonly used method for limiting cognitive resource – particularly in the
161 context of labelling - is inducing time pressure, with the available evidence suggesting that
162 limited time prevents people from accessing all available cognitive resources, making non-
163 reflective or impulsive behaviour more likely (34, 36, 37).

164 The primary aim of the current study was to assess the impact on selection of alcoholic
165 beverages of different types of HWLs communicating the risk of cancer related to alcohol
166 consumption: (a) image-and-text (b) text-only and (c) image-only. We hypothesised that text-
167 only and image-and-text HWLs would decrease selection of alcoholic drinks compared to
168 image-only HWLs and no HWL. The secondary aims were to assess *i.* the impact of HWLs on
169 emotional and cognitive responses - including negative emotional arousal, reactance,
170 avoidance, and acceptability and *ii.* the impact of limited cognitive resource on selection of
171 alcoholic drinks with HWLs.

172 **Methods**

173 The study protocol and a detailed analysis plan were pre-registered on the Open Science
174 Framework (<https://osf.io/pr8zu/>).

175 **Design**

176 The study was conducted on the online survey platform Qualtrics, using a between-subjects 2
177 (image: present v absent) x 2 (text: present v absent) factorial experimental design.
178 Participants were randomised via the Qualtrics platform to one of four possible experimental
179 groups (Box 1).

180 [Insert Box 1]

181 **Participants**

182 Participants were adults over the age of 18, who consumed beer or wine regularly (i.e., at least
183 once a week), recruited through a market research agency (<https://www.dynata.com/>). The
184 research agency set quotas for age and gender to recruit a representative sample of the UK
185 general population, in terms of age and gender.

186 Based on previous research assessing the impact of different warning labels on selection of
187 sugar-sweetened beverages (38), the expected difference in the proportion of participants
188 selecting an alcoholic beverage between the different label type groups was expected to be
189 5.7%, decreasing from 38.2% to 32.5%. To detect this difference with power = 0.8, and alpha
190 = 0.0167 (applying Bonferroni adjustment for 3 separate comparisons between the four
191 groups), it was calculated that at least 1497 per label group were needed, giving a minimum
192 sample size requirement of 5988.

193 **Interventions**

194 Label design

195 The specific adverse health consequences illustrated by the HWLs were chosen based on the
196 results of another study (30), which aimed to identify the images eliciting the highest levels
197 of negative emotional arousal and the lowest desire to consume the product. The three HWLs
198 selected depicted bowel cancer, breast cancer and liver cancer. The same health consequences
199 were used for each HWL group (image-and-text, text-only, image-only). In the control group,
200 branded labels were displayed on the products in their original form. In the HWL groups
201 brand information was moved so it remained clearly visible. The labels used in the study
202 were prepared by a graphic designer (see <https://osf.io/6dx2u/> for study stimuli). Full details
203 on the selection process and the labels that were ultimately used in the current study can be
204 found in the Supplementary Material (S1).

205 **Outcomes**

206 Primary outcome

207 *Selection task.* Participants first viewed images of 12 drinks (six alcoholic and six soft
208 drink/non-alcoholic alternatives) in turn. All drinks - alcoholic and non-alcoholic - were
209 branded, comprising a variety of different brands. The six non-alcoholic drinks comprised three
210 different soft drinks and three different alcohol-free beers or wines. Whether the options shown
211 were beer or wine depended on participant preference specified at the start of the study.
212 Participants then viewed images of all the 12 drinks simultaneously, in random order, and were
213 asked to choose one they would like to consume either immediately or later on that day - to
214 reduce the likelihood of decisions being made based on the time of day. Depending on their
215 allocated group, the alcoholic drinks displayed either no HWL or one of three warning label
216 types (image-and-text, text-only, image-only). In the HWL groups, each alcoholic drink
217 displayed one of the three different HWLs, i.e., one of the three health consequence labels, so
218 that each health consequence was shown twice - *i.e.* on two drinks - across the selection. The
219 outcome was the proportion of participants selecting an alcoholic beverage (beer or wine).

220 Secondary outcomes

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221 *Negative emotional arousal*, assessed using a four-item measure, previously used to assess the
222 impact of warning labels on cigarette packages (39). Responses were rated on seven point
223 scales: ‘How [afraid/worried/ uncomfortable/disgusted] does the label on this drink make you
224 feel?’ (0 Not at all [afraid / worried / uncomfortable / disgusted] to 7 very [afraid / worried /
225 uncomfortable / disgusted]).

226
227 *Reactance and avoidance (defensive reactions)*, assessed using two items, previously used to
228 assess the impact of warning labels on alcohol products (25). The items were from a 27-item
229 scale developed by (40) for reactance to tobacco health warnings. Responses were rated on
230 seven point scales: (0 Not at all to 7 very [annoying / likely]) to both items: ‘Are these labels
231 annoying?’; ‘Are you likely to avoid these labels?’

232
233 *Acceptability of health warning labels*, assessed using one item on a seven point scale, adapted
234 from previous research assessing the impact of sugar tax (41): ‘Do you support or oppose
235 putting this label on alcoholic drinks?’ (Strongly oppose – neither oppose nor support –
236 strongly support). Ratings past the midpoint (indicating neither acceptable nor unacceptable),
237 *i.e.* above 4 on the scale, were taken to indicate that the label was acceptable.

238
239 *Perceived disease risk relating to drinking the alcoholic beverage*, assessed using a three-item
240 measure on seven point scales adapted from previous research used to assess the impact of
241 warning labels on sugar-sweetened beverages (42): ‘Consuming this drink often would
242 [increase your risk of [cancer/liver disease] / help you lead a healthier life]’ (Strongly disagree
243 – neither agree nor disagree – strongly agree). Scores for the three items were combined into a
244 total ‘disease risk’ score, with scores reversed for item three: ‘help you lead a healthier life’.

245
246 *Selection in relation to cognitive resource manipulation*, adapted from previous research on
247 front-of-pack nutrition labelling (35, 37). After the first selection task, participants were
248 randomised to select a drink under either high (3 seconds) or no time pressure (60 seconds)
249 from six pairs of alcoholic and non-alcoholic drinks (soft drink or zero alcohol) either for
250 immediate consumption or later on that day. The alcoholic drinks displayed either had no HWL
251 or one of the three HWLs depending on randomisation. Participants were required to make a
252 selection six times from six different pairs. The outcome was the number of times an alcoholic
253 drink was selected (a score from 0-6). Not selecting a drink was a possible option. Not selecting
254 a drink and selecting a non-alcoholic drink were each coded as zero.

255

256 **Procedure**

257 Ethical approval for this study was granted by the Cambridge Psychology Research Ethics
258 Committee (reference: PRE.2018.072). After consenting to participate, participants completed
259 screening questions relating to their normal consumption of alcohol. Eligible participants were
260 asked questions regarding their demographic characteristics (age, gender, ethnicity, education
261 level, household income) and preferred type of alcoholic beverage (beer or wine) to determine
262 the drinks to be viewed in the subsequent task. After completing the screening and demographic
263 questions, participants were randomised to one of four possible experimental groups (Box 1)
264 and were asked to complete all tasks and measures. Participants could not proceed without
265 answering all questions. Prior to randomisation, inattentive participants were screened out via
266 an attention check embedded in the study (those not answering ‘never’ to the question: ‘When
267 did you last fly to Mars?’) and sampling continued until the quota was filled. All participants

268 who successfully completed the study were debriefed and reimbursed for their participation.
269 Data were collected in February 2019.

270 Eligible participants first completed the selection task (see primary outcome). Participants then
271 viewed an image of a beer or wine bottle with or without a HWL depending on their allocated
272 group, and were asked to complete questions relating to their perceptions and attitudes toward
273 the HWL (or towards a branded product with no HWL for those in the control group). For the
274 acceptability outcome only, participants in the no label group were re-randomised to one of the
275 other three HWL groups. Participants were then randomised to a time pressure group and
276 completed a second selection task (see secondary outcomes), followed by measures of drinking
277 characteristics (AUDIT-C (43), weekly consumption), height and weight.

278 **Statistical analysis**

279 Descriptive statistics compared baseline characteristics of those allocated to different types of
280 warning label. Logistic regressions were performed to assess the odds of selecting an alcoholic
281 beverage in each group, using the ‘no HWL’ group as the reference category. The factorial 2 x
282 2 design was exploited by assessing the impact of text and image simultaneously, and the
283 interaction between the two. Each effect was calculated as an odds ratio (OR) with 95%
284 confidence intervals (CIs), along with the corresponding p-value.

285 For four of the continuous secondary outcomes, normality was assessed, and 2 x 2 ANOVA
286 (analysis of variance) models were used to compare the impact of text and image between study
287 arms. For analysis of the remaining acceptability outcome a one-way ANOVA was conducted
288 between the three study arms. A general linear model using a 2 x 2 x 2 design assessed the
289 differences in the number of alcoholic drinks selected between the two time-pressure groups
290 (time pressure vs. no time pressure) and the impact of text and image.

291 Analyses of all secondary outcomes were repeated using a bootstrapping method, using 1000
292 bootstrap samples due to deviations from normality in their distributions: results were very
293 similar (Supplementary Material: Table S5). The effect size for all secondary outcomes was
294 a difference in means, with 95% CIs, F statistics, p-values and Cohen’s *d* all reported. As an
295 exploratory analysis, negative emotional arousal was added to the primary logistic regression
296 model as a covariate to assess the potentially mediating role of negative emotional arousal.

297 A detailed analysis plan was registered (registration details: <https://osf.io/ntq63/>).

298 **Results**

299 In total, 6087 participants were randomised and 6024 participants completed the study.
300 Figure 1 shows the flow of participants through the study and Table 1 their characteristics
301 across groups. Half of the sample were female and the mean age was 49.5 (SD = 15.5).
302 Groups were well balanced on all characteristics.

303 [Insert Figure 1]

304 [Insert Table 1]

305 **Primary outcome**

306 Alcoholic drink selection was lower when drinks displayed a HWL compared to when no
307 HWL was used (see Table 2). Absolute reductions in percentages compared to no HWL

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308 were: image and text: 21% (95% CI = 18%, 24%), image-only: 28% (95% CI = 25%, 31%)
309 and text only: 16% (95% CI = 12%, 19%). All HWLs decreased the odds of selecting an
310 alcoholic drink. Compared to no HWL, the odds of selecting an alcoholic drink was 61%
311 lower for the image-and-text HWL (odds ratio (OR) = 0.39, 95% CI 0.33-0.45); 52% lower for
312 the text-only HWL (OR = 0.48, 95% CI 0.41-0.57) and 71% for the image-only HWL (OR =
313 0.29; 95% CI 0.25-0.34).

314 The results of a factorial 2 (text vs. no text) x 2 (image vs. no image) analysis provided
315 evidence of a main effect of including text (OR = 0.84, 95% CI = 0.76, 0.93, $p = 0.001$), an
316 image (OR = 0.49, 95% CI = 0.44, 0.54, $p < 0.001$) and an interaction between the two
317 factors ($p < 0.001$). HWLs displaying images (image-and-text HWL: 56%; image-only HWL:
318 49%) decreased alcoholic drink selection compared to text alone (61%) and no HWL (77%).
319 Adding an image to text reduced the odds of selecting an alcoholic drink, meaning that
320 image-and-text HWLs reduced selection compared to text-only HWLs (OR = 0.80, 95% CI =
321 0.69, 0.92, $p = 0.002$). Adding text to an image increased the odds of selecting an alcoholic
322 drink, meaning that image-and-text HWLs increased selection compared to image-only
323 HWLs (OR = 1.34, 95% CI = 1.16, 1.55, $p < 0.001$).

324 [Insert Table 2]

325 **Secondary outcomes**

326 Secondary outcome data are presented in Table 2. Compared to not having any label, all
327 HWLs increased scores on each secondary outcome – negative emotional arousal, reactance,
328 avoidance and disease risk (all $ps < 0.001$).

329 The main effects of image, text and the image x text interaction for all four 2 x 2 ANOVA
330 models showed evidence of significant effects (all $ps < 0.001$) (Supplementary Material,
331 Table S2, Figure S2). For negative emotional arousal, reactance and avoidance adding an
332 image to text increased scores (all $ps < 0.001$). For avoidance only, there was clear evidence
333 that adding text to an image decreased scores ($p = 0.018$). There was a very weak suggestion
334 of a similar pattern for reactance and negative emotional arousal scores. Perceived disease
335 risk in all three HWL groups did not show evidence of being different from each other. Mean
336 differences between each HWL group and the no HWL group are shown in Table 3.

337 [Insert Table 3]

338 Acceptability of the HWLs

339 Image-and-text HWLs were less accepted than text-only HWLs (mean difference (MD) =
340 0.27 95% CI = 0.15, 0.38, $p < 0.001$, $d = 0.15$), and were more accepted than image-only
341 HWLs (MD = -0.47 95% CI = -0.59, -0.36, $p < 0.001$, $d = -0.25$) (Table 2). Overall, 31.74%
342 of participants rated HWLs as acceptable (text-only HWLs: 37.33%; image-and-text HWLs:
343 34.18%; image-only HWLs: 23.65%). A sensitivity analysis was conducted which included
344 only those participants who were assigned to their original group ($n = 4514$, *i.e.* it excluded
345 the control group who were re-randomised). The results were similar to the main analysis
346 (see Supplementary Material S3).

347 Cognitive resource manipulation

348 There was a main effect of time pressure (MD = 0.76 95% CI = 0.66, 0.86, $p < 0.001$, $d =$
349 0.39), indicating that participants selected fewer alcoholic drinks when they were under time
350 pressure in all groups (Table 2). There was no evidence of an interaction between time
351 pressure and HWL group ($p = 0.40$). As non-selections were coded identically to non-
352 alcoholic drink selections, a sensitivity analysis was conducted, coding the non-selections as
353 alcoholic drink selections. The descriptive statistics were similar to the main analysis for the
354 differences between HWL groups (see Supplementary Material S4). However, the results for
355 the differences in alcohol selection under time pressure were in the opposite direction, with
356 more alcoholic drinks selected, due to more non-selections under time pressure (mean non-
357 selections under time pressure: 1.73; no time pressure: 0.14).

358 Mediating effect of negative emotional arousal

359 As an exploratory analysis, negative emotional arousal was added to the primary logistic
360 regression model as a covariate. The odds ratio for selecting an alcoholic drink associated
361 with a text-only HWL changed from 0.48 before adjusting for negative emotional arousal, to
362 1.11 (95% CI 0.93, 1.13) after adjustment, while that for an image-only HWL adjusted from
363 0.29 before, to 0.84 (95% CI 0.69, 1.01) after, and for an image-and-text HWL adjusted from
364 0.39 to 1.11 (95% CI 0.92, 1.34) (Table 4). The model suggested possible mediation by
365 negative emotional arousal of the effect of HWLs on alcohol selection.

366 [Insert Table 4]

367 **Discussion**

368 In an online selection task, placing HWLs on bottles of wine or beer communicating the
369 increased risk of specific cancers associated with alcohol consumption reduced selection of
370 alcoholic drinks. HWLs displaying images were more effective at reducing selection than text-
371 only HWLs, with image-only HWLs most effective at decreasing selection. This pattern of
372 findings partly supported our hypotheses in showing that image-and-text and text-only HWLs
373 decreased selection of alcohol, but we did not predict that image-only HWLs would be most
374 effective.

375 These findings are consistent with evidence that HWLs decrease selection of other harmful
376 products, such as tobacco and sugar-sweetened beverages (10, 38). They are also consistent
377 with results from laboratory and online studies suggesting that text-only and image-and-text
378 HWLs lower intentions to consume alcohol and reduce speed of consumption (21, 22, 25, 28).
379 In the current study, although all HWLs reduced selection, labels containing images had the
380 largest effects, even without text. The greater effectiveness of images with text compared to
381 text-only is in line with evidence from tobacco research (10, 12, 15). One explanation for the
382 superiority of image-based labels is that they arouse more negative emotion than text-only
383 HWLs (16), with this also observed in the current study. An exploratory analysis also suggested
384 a possible mediation of the impact of all HWLs on selection by negative emotional arousal *i.e.*
385 HWLs increase negative emotional arousal which in turn impacts selection. However, the
386 current study design precluded testing whether this was a causal relationship as negative
387 emotional arousal was measured following the primary outcome. Future studies would need to
388 be designed to examine the causal relationship between these variables.

389 Image-only HWLs reduced selection to a greater extent than image-and-text HWLs, suggesting
390 that an interpretative text statement is not necessary for effectiveness – at least when the content

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391 of images is sufficiently understandable or interpretable - and that this may even reduce the
392 impact of the image. Supporting evidence from food research shows that pairing less healthy
393 snack foods with aversive images of negative consequences without text statements can reduce
394 product selection (31, 32). Future studies should assess whether the relevance of an image to
395 health is important for label effectiveness, or whether simply the aversive nature of any image
396 is sufficient to change behaviour. In the current study, avoidance of the label was increased
397 when labels were displayed without the text statement, suggesting a textual description may be
398 important in attenuating the likely avoidance of labels containing aversive images. Any
399 accompanying text on a label should not however distract from an image, which seems the key
400 component for maximum impact.

401 All of the HWLs increased defensive reactions - reactance and avoidance - compared to no
402 HWL, with scores for both highest for HWLs with an image. The effect sizes for the difference
403 in scores in the HWL groups compared to no HWL were large (with all Cohen's *d* values over
404 1), although – as with all secondary outcomes - this study cannot elucidate the practical
405 consequences of these differences. Furthermore, the impact of a public health intervention will
406 be a function of its effect size and scale of application – a small effect that influences the
407 behaviour of a very large number of people (as is conceivably the case here) could potentially
408 be very important. These results are consistent with the findings from another online study,
409 which showed larger increases in self-report measures of reactance and avoidance for more
410 severe images on alcohol HWLs (28). In addition, evidence of defensive reactions does not
411 necessarily indicate lack of effectiveness – as demonstrated in the current study and previous
412 research on tobacco HWLs (44).

413 Perceived disease risk was increased with all HWLs compared to no HWL suggesting that
414 HWLs have the potential to increase the currently low awareness of alcohol harms, such as the
415 alcohol-cancer link (8). An increase in awareness of alcohol harms may also increase HWL
416 acceptability, which was low in the current study. Overall, only 32% of participants rated the
417 HWLs as acceptable to some degree, with the HWLs that were most effective –those with
418 images - being least acceptable, although the differences were small. This is consistent with
419 evidence of the most effective interventions being the least accepted (45). However, low scores
420 may be more representative of the study population of regular alcohol drinkers than the wider
421 population. Those that drink more heavily may see alcohol as more socially acceptable (46)
422 and have reduced perceptions of alcohol risk susceptibility (28). Some studies have found
423 relatively high public acceptability for alcohol HWLs, but in neither study were participants
424 shown examples of the images (47, 48). With increased awareness of health risks alongside
425 demonstrated effectiveness, acceptability of HWLs may increase (41). A recent field study
426 investigating the impact of HWLs on purchasing alcohol focused on communicating risks of
427 cancer from alcohol consumption. These labels increased knowledge of the link between
428 alcohol consumption and cancer, which was associated in turn with increased support for
429 alcohol control policies such as pricing policies (49). This study was halted due to pressure
430 from the alcohol industry and continued without the cancer HWLs – highlighting potential
431 challenges from industry to interventions that associate their products with health harms (50).

432 Findings from the cognitive resource manipulation indicated that, across all groups, fewer
433 alcoholic drinks were selected under time pressure. This was in the opposite direction to that
434 anticipated, with reduced cognitive resources leading to less healthy choices (33). However, in
435 the current task, it was possible for participants to not select any drink, and so it may be that

436 not making any selection was more likely when time was limited. Supporting this possible
437 interpretation, we found there were more non-selections in the time pressure group and a
438 sensitivity analysis (coding the non-selections as alcoholic drinks instead of non-alcoholic
439 drinks, as was done in the original analysis) was in the opposite direction to the original results,
440 with more alcoholic drinks selected under time pressure due to the higher number of non-
441 selections. There was no interaction between time pressure and HWL group, indicating that the
442 impact of the HWLs did not differ under low resource, which is not in line with findings from
443 previous studies (34, 35). This could be due to the nature of the task. First, participants were
444 required to choose between two drinks; it may be that the alcohol-free drinks were disliked or
445 too unfamiliar, supported by a low proportion of participants selecting them in the main
446 selection task: of those who selected a non-alcoholic drink, fewer than a third selected alcohol
447 free wine or beer. Second, the time pressure task may have been too artificial to adequately
448 induce cognitive load, this being difficult to manipulate in an online setting.

449 **Implications**

450 The current study findings indicate that image-and-text, text-only and image-only HWLs can
451 reduce hypothetical selection of alcohol in an online study. However, findings do not
452 necessarily translate to other more naturalistic settings (51), and further evaluation of these
453 HWLs is now required in laboratory and field settings. Evidence of effectiveness in these
454 contexts would provide support for current recommendations from alcohol public health bodies
455 for larger, prominent labels that clearly describe alcohol-related harms (52).

456 **Strengths and limitations**

457 This pre-registered study provides the most robust evidence to date of the potential for HWLs
458 communicating the increased risk of cancer, designed in line with tobacco HWL guidelines
459 (14), to reduce selection of alcohol in an online setting.

460 The study design conferred some limitations. First, the setting was artificial, involving the use
461 of images of products and a hypothetical selection task with a limited product range.
462 Although important to highlight the HWLs with the most potential, subsequent evaluation is
463 now needed in more realistic settings. Second, and relatedly, most of the secondary outcome
464 measures were assessed using self-report. As evidence in this context indicates subjective
465 measures may differ from objective measures (28), future study designs should incorporate
466 both.

467 **Conclusions**

468 Health warning labels communicating the increased risk of cancers associated with alcohol
469 consumption can reduce selection of alcoholic drinks in an online setting, with labels
470 displaying images having the largest effect. These labels now need to be evaluated in laboratory
471 and field settings with physical products, using objective measures.

472 **Authors' contributions**

473 GJH, TMM, NC, EP, EM and AKMB conceived the study and collaborated in designing the
474 procedures. NC and EP coordinated the study and data collection. KD, MM and RKM
475 performed the data analyses. NC and GJH drafted the manuscript, with all authors providing
476 critical revisions. All authors read and approved the final manuscript.

477 **Ethics approval and consent to participate**

478 Approved by the Psychology Research Ethics Committee of the University of Cambridge
479 (Reference Number: PRE.2018.072). All participants provided informed consent.

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662 **Box 1. Study design**

	Image of adverse health consequence	
Health consequence – text statement	Present	Absent
Text	<p>Group 1 Image-and-text HWL</p> 	<p>Group 2 Text-only HWL</p> 
No text	<p>Group 3 Image-only HWL</p> 	<p>Group 4 No image No health consequence</p>

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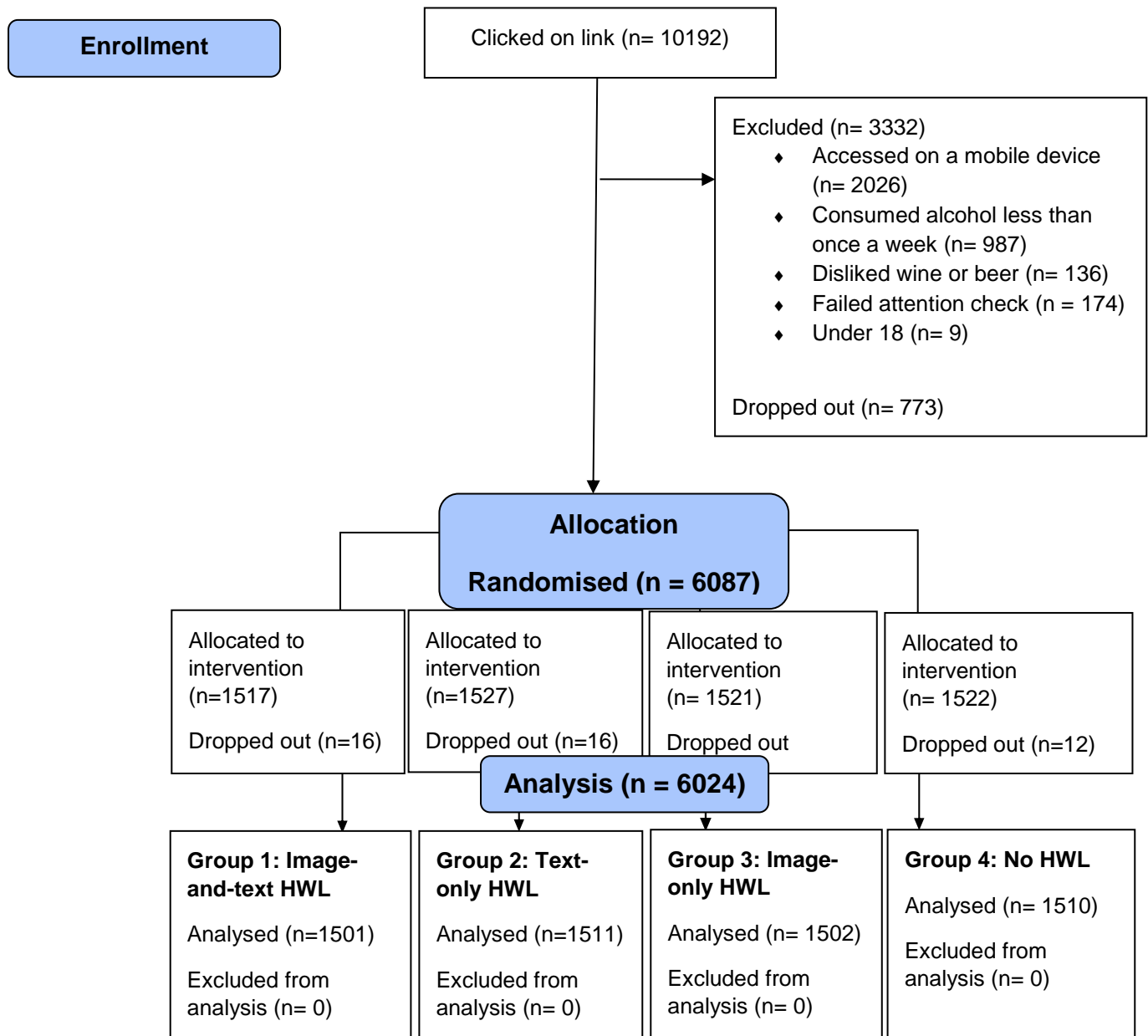
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Figure 1. Flow of participants through study



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Table 1. Participant characteristics (n (%), unless otherwise stated)

	Group 1: Image-and-text HWL n = 1501	Group 2: Text-only HWL n = 1511	Group 3: Image-only HWL n = 1502	Group 4: Control (no HWL) n = 1510
Weekly consumption (units)¹				
0-14	768 (51%)	728 (48%)	745 (50%)	751 (50%)
15-30	402 (27%)	433 (29%)	382 (25%)	398 (27%)
31-50	159 (11%)	179 (12%)	189 (13%)	187 (12%)
51-99	119 (8%)	113 (8%)	128 (9%)	117 (8%)
100+	41 (3%)	52 (3%)	48 (3%)	48 (3%)
Missing	12	6	10	9
Preferred drink				
Wine	667 (44%)	626 (41%)	659 (44%)	669 (44%)
Beer	834 (56%)	885 (59%)	843 (56%)	841 (56%)
AUDIT² score (mean +/- SD)	5.4 (2.5)	5.5 (2.5)	5.5 (2.6)	5.5 (2.5)
Age (mean +/- SD)	49.7 (15.6)	49.4 (15.6)	49.1 (15.2)	49.7 (15.6)
18-39 years	451 (30%)	453 (30%)	450 (30%)	464 (31%)
40-59 years	572 (38%)	589 (39%)	584 (39%)	615 (41%)
60 and over	482 (32%)	468 (31%)	465 (31%)	419 (28%)
Gender				
Male	779 (52%)	725 (48%)	749 (50%)	757 (50%)
Female	721 (48%)	784 (52%)	749 (50%)	752 (50%)
Other	0	1 (<1%)	3 (<1%)	0
Prefer not to say	1	1	1	1
Ethnicity				
White	1401 (93%)	1416 (94%)	1402 (93%)	1410 (93%)
Mixed	26 (2%)	26 (2%)	23 (2%)	29 (2%)
Asian	42 (3%)	44 (3%)	43 (3%)	43 (3%)
Black	15 (1%)	14 (1%)	21 (1%)	17 (1%)
Other ethnic group	5 (<1%)	2 (<1%)	2 (<1%)	2 (<1%)
Prefer not to say	12	9	11	9

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Education

No Bachelor's degree	732 (49%)	831 (55%)	751 (50%)	754 (50%)
Bachelor's degree or higher	765 (51%)	675 (45%)	749 (50%)	753 (50%)
Prefer not to say	4	5	2	3

Standard deviation (SD). Health warning label (HWL). Note: Missing/prefer not to answer data is listed in the table but all % are valid %.

¹ All participants in the sample explicitly reported drinking at least once a week in the screener questions. A further weekly drinking measure recorded the amount of alcohol consumed in the previous week as an overall indication of the volume of alcohol consumed weekly.

² Heavy and binge drinking behaviours (AUDIT-C), three questions to detect heavy and binge drinking behaviour in a general population, with a total score of 0 (low risk) to 12 (high risk) (43)

Table 2. Primary (% (n)) and secondary outcomes (mean (SD))

	Group 1 Image-and-text HWL n = 1501	Group 2 Text-only HWL n = 1511	Group 3 Image-only HWL n = 1502	Group 4 Control (no HWL) n = 1510
PRIMARY				
Proportion choosing alcoholic beverage	56% (837)	61% (926)	49% (728)	77 % (1157)
				-
SECONDARY (scale range)				
Negative emotional arousal (1-7)	4.12 (1.71)	3.53 (1.66)	4.23 (1.80)	1.55 (1.20)
Reactance (1-7)	4.66 (1.93)	4.32 (1.96)	4.78 (1.89)	1.66 (1.29)
Avoidance (1-7)	4.32 (1.99)	3.77 (1.92)	4.49 (2.07)	1.96 (1.62)
Perceived disease risk (3-21)	14.99 (3.43)	14.76 (3.30)	15.05 (3.34)	13.16 (3.35)
Acceptability ¹ (1-7)	3.60 (1.91)	3.87 (1.76)	3.13 (1.81)	-
Number of alcoholic drinks selected (0-6) with cognitive resource manipulation				
With time pressure	2.25 (1.93)	2.34 (1.85)	2.14 (1.97)	2.37 (1.65)
With no time pressure	3.08 (2.19)	3.14 (2.06)	2.75 (2.19)	3.17 (1.90)

Standard deviation (SD). Health warning label (HWL).

¹re-randomisation, into one of the other 3 groups, occurred for the no image group therefore the total n for this variable were: text-only n = 2020, image-only n = 2000 and text+image n = 2004. The reference group for this analysis was the text-only condition.

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Table 3. Mean differences between HWL groups and no HWL for secondary outcomes.

Secondary outcome	Mean difference compared with no HWL (95% CI), p value, effect size (Cohen's <i>d</i>)		
	Group 1 Image-and-text HWL (n = 1501)	Group 2 Text-only HWL (n = 1511)	Group 3 Image-only HWL (n = 1502)
Negative emotional arousal	2.57 (2.46, 2.69) <i>p</i> < 0.001, <i>d</i> = 1.74	1.98 (1.87, 2.10) <i>p</i> < 0.001, <i>d</i> = 1.37	2.68 (2.56, 2.80) <i>p</i> < 0.001, <i>d</i> = 1.75
Reactance	3.00 (2.83, 3.17) <i>p</i> < 0.001, <i>d</i> = 1.82	2.66 (2.49, 2.83) <i>p</i> < 0.001, <i>d</i> = 1.60	3.12 (2.94, 3.28) <i>p</i> < 0.001, <i>d</i> = 1.92
Avoidance	2.36 (2.23, 2.50) <i>p</i> < 0.001, <i>d</i> = 1.30	1.82 (1.68, 1.95) <i>p</i> < 0.001, <i>d</i> = 1.01	2.53 (2.39, 2.67) <i>p</i> < 0.001, <i>d</i> = 1.36
Perceived disease risk ¹	1.83 (1.59, 2.07) <i>p</i> < 0.001, <i>d</i> = 0.53	1.60 (1.36, 1.84) <i>p</i> < 0.001, <i>d</i> = 0.48	1.89 (1.65, 2.13) <i>p</i> < 0.001, <i>d</i> = 0.57
	Mean difference compared with image-and-text HWL (95% CI), p value, effect size (Cohen's <i>d</i>)		
	Group 1 Image-and-text HWL (n = 2004)	Group 2 Text-only HWL (n = 2020)	Group 3 Image only HWL (n = 2000)
Acceptability	- -	0.27 (0.15, 0.38) <i>p</i> < 0.001, <i>d</i> = 0.15	-0.47 (-0.59, -0.36) <i>p</i> < 0.001, <i>d</i> = -0.25

Confidence interval (CI). Health Warning Label (HWL).

¹aggregate measure of 3 items (cancer, liver disease, perceived healthiness of the drink)

Table 4. Exploratory mediation analysis (negative emotional arousal) for the primary outcome (was an alcoholic drink selected)

HWL group	Type of drink selected		Model effects [^]		Model effects (including negative emotional arousal as a covariate) ^{^^}	
	Non-alcoholic	Alcoholic	OR (95% CI)	<i>p</i> value	OR (95% CI)	<i>p</i> value
Control (n=1510)	353 (23)	1157 (77)	-	-	-	-
Text only (n=1511)	585 (39)	926 (61)	0.48 (0.41, 0.57)	< 0.001	1.11 (0.93, 1.32)	0.270
Image only (n=1502)	774 (52)	728 (49)	0.29 (0.25, 0.34)	< 0.001	0.84 (0.69, 1.01)	0.059
Image-and-text (n=1501)	664 (44)	837 (56)	0.39 (0.33, 0.45)	< 0.001	1.11 (0.92, 1.34)	0.278

Odds ratio (OR). Confidence interval (CI). Health warning label (HWL).

[^]model includes the main effect of HWL group only.

^{^^}model includes the main effect of HWL group and negative emotional arousal as a covariate.