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Dietary intake, nutritional status and mental wellbeing of homeless adults in Reading, UK¹⁻⁴

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Running Head: Nutrition in homeless compared to housed adults

Keywords: homelessness, mental health, nutrient intake, dietary methodology, nutrition intervention

Abbreviations: CVD, cardiovascular disease; DRV, dietary reference value; EPIC, European Prospective Investigation into Cancer and Nutrition; FETA, FFQ EPIC tool for analysis; NSP, non-starch polysaccharides; PHQ-SADS, patient health questionnaire: somatic anxiety depressive symptoms; RNI, recommended nutrient intake; %E, percentage of total energy intake.

1 **Abstract**

2 Malnutrition has been reported in the homeless, yet the specific nutritional issues faced by each
3 homeless community are unclear. This is in part due to nutrient intake often being compared to
4 dietary reference values as opposed to a comparative housed population. Additionally, the
5 complex interplay between nutrient intake, reward mediated behaviour and mental illness has
6 frequently been overlooked. This observational study aimed to compare the dietary intake,
7 nutritional status and mental wellbeing of homeless and housed adults. Homeless ($n=75$) and
8 matched housed ($n=75$) adults were recruited from the Reading region (UK). Nutrient intake was
9 determined using the EPIC Norfolk Food Frequency Questionnaire. The Patient Health
10 Questionnaire: Somatic Anxiety Depressive Symptoms (PHQ-SADS) assessed for signs indicative
11 of mental illness. Demographic, behavioural and physiological information was collected using
12 closed-ended questions and anthropometric measurements. Overall, dietary intake was poorer in
13 homeless adults who reported higher intakes of salt (8.0g vs. 6.4g, $P=0.017$), SFA (14.6% vs.
14 13.0%, $P=0.002$) and alcohol (5.3% vs. 1.9%, $P<0.001$) and lower intakes of fibre (13.4g vs. 16.3g,
15 $P<0.001$), vitamin C (79mg vs. 109mg, $P<0.001$) and fruit (96g vs. 260g, $P<0.001$) than housed
16 adults. Smoking, substance misuse and PHQ-SADS scores were also higher in the homeless
17 group ($P<0.001$). Within the homeless population, street homeless ($n=24$) had lower SFA (13.7%
18 vs.15.0%, $P=0.010$), calcium (858mg vs. 1032mg, $P=0.027$) and milk intakes (295g vs. 449g,
19 $P=0.001$) than hostel residents ($n=51$), which may reflect the issues with food storage in street
20 homeless individuals. This study highlights the disparity between nutritional status in homeless and
21 housed populations and the need for dietary intervention in the homeless community.

22 Introduction

23 Homelessness is a global issue. In England, over 68,500 households in 2015 were classified as
24 homeless ⁽¹⁾ and a further 3,569 were considered rough sleepers ⁽²⁾. The lack of stable
25 accommodation, in conjunction with a low or absent income, raises challenges for the homeless,
26 one of which is access to food, although this is likely to differ between rough sleepers and those in
27 temporary accommodation. However despite the widespread prevalence of homelessness,
28 relatively few studies have sought to determine the nutritional status of these individuals, a
29 situation that may partly reflect the difficulty in collecting data from this transient population.

30 Despite this, several themes have emerged from studies to date, including a high SFA, low fruit
31 and vegetable diet ⁽³⁻⁶⁾, elevated serum cholesterol ⁽⁷⁾ and low levels of vitamin B-6, calcium and
32 iron^(7; 8), although findings have not been consistent between countries. For example, lower skin-
33 fold thickness and muscle mass measurements have demonstrated 'wasting' in homeless
34 communities in Germany and the US (1989-2001) ^(4; 7; 8), whereas others have found a proportion
35 of homeless that, according to their BMI, are overweight or obese in the US (2012-2013) ^(9; 10).

36 In the presence of physiological stresses arising from exposure to harsh environmental
37 conditions, the absence of a nutritionally balanced diet is likely to have a detrimental impact on the
38 health of a homeless individual. Elevated levels of acute and chronic disease ^(11; 12), increased
39 visits to emergency departments ⁽¹³⁾ and an average age of death of 47 years in the UK ⁽¹⁴⁾
40 highlight the additional challenges faced by the homeless community. Cardiovascular disease
41 (CVD), for which diet is a key modifiable factor, is reported as the leading cause of mortality in
42 homeless adults between 45-65 years, ^(15; 16).

43 A higher prevalence of mental illness (e.g. depression, anxiety) in the homeless compared to the
44 general population has also been reported ^(12; 17). Reward mediated behaviors such as problematic
45 alcohol use, smoking and substance misuse are also frequently described ^(4; 12). The reported
46 substitution of food with alcohol by alcoholic homeless individuals ⁽⁴⁾ and the use of money for illicit
47 substances as opposed to food in homeless drug addicts ⁽¹²⁾ demonstrates the potential nutritional
48 consequences arising from reward mediated behavior. Addictive substances may also impact upon
49 the absorption, metabolism and/or requirements for nutrients ^(18; 19).

50 Habitual diets and culture limit the extent to which nutrient intake of the homeless is comparable
51 between countries or regions ⁽²⁰⁾. Furthermore, studies have often failed to account for the impact
52 of physical and mental wellbeing on dietary intake; do not use a control group and have
53 widespread reliance on dietary reference values (DRV), which is potentially misleading. Comparing
54 homeless and housed individuals within the same region would overcome this issue, providing a
55 more accurate assessment of homeless intake in the specific location. However such studies are
56 currently lacking.

57 The aim of the present research was to compare nutritional status, dietary intake and mental
58 wellbeing in a group of homeless with age and gender-matched housed individuals (control group)
59 in Reading, UK. A secondary aim was to establish the marginal impact of homeless status (e.g.
60 street homeless vs. hostel residents) on these parameters.

61

62 **Methods**

63 *Participants and study design*

64 In this cross-sectional observation study homeless (n=75) and housed (n=75) men and women
65 were recruited. During recruitment, the two groups were broadly matched on the basis of age
66 range (18-29, 30-39, 40-49, >50yrs), gender and ethnicity. In order to capture homeless individuals
67 at the more extreme stages of homelessness this study only included individuals 'living rough' on
68 the street and those in the initial stages of housing (supported living). Street homeless were
69 recruited from a church drop-in centre that provides hot meals. Two hostels (charity and council
70 led) were used to recruit individuals residing in 'stage 1' accommodation. In addition to
71 accommodation for adults previously living on the street, the charity-led hostel also provides 'in
72 house' meals. Recruitment posters were displayed in each venue by staff, and residents/clients
73 recruited on a first-come basis. Housed volunteers were recruited at random through a volunteer
74 database at the Hugh Sinclair Unit of Human Nutrition, Reading, and via posters displayed at
75 Reading central library and around the Reading University campus. The University of Reading
76 School of Chemistry, Food and Pharmacy Research Ethics Committee (Approval number: 20/14)
77 and The Salvation Army Ethics Committee granted ethical approval for the study. All participants
78 gave informed written consent prior to participation.

79 *Data Collection*

80 Each participant completed three questionnaires during a single research session. A room was
81 provided at each venue for the purpose of the study and one of four trained researchers and a
82 volunteer from the specific venue were present during each session. Each volunteer was provided
83 with the option of either completing the questionnaires themselves or being asked the questions by
84 the researcher. For those opting to self-complete the questionnaires, responses were checked and
85 verified prior to departure. Questionnaires took between 60-90 minutes to complete. Volunteers
86 were reimbursed for their participation in the study via a £10 shopping voucher.

87 *Questionnaires*

88 To assess nutrient intake, the European Prospective Investigation into Cancer and Nutrition
89 (EPIC)-Norfolk FFQ was used. The FFQ is a validated semi-quantitative questionnaire consisting
90 of 130 food and drink items ^(21; 22). For each item the participant is required to choose one out of 9
91 possible frequency options ranging from 'never/less than once a month' to '6+ per day'. FFQs are
92 typically completed with reference to the preceding 6 months to 1 year. However to ensure
93 reported nutrient intake related to the time an individual was homeless, participants were asked to
94 complete the FFQ with reference to the last month only, as some had been homeless for one to
95 two months. FFQ EPIC tool for analysis (FETA) software was used to determine daily nutrient
96 levels from the FFQ responses, which is based upon McCance and Widdowson's The Composition
97 of Foods (5th edition) and its supplements ⁽²³⁾. Energy, macronutrients (including sub-classes of fats
98 and carbohydrates), key vitamins and minerals (associated with public health concerns), and 14
99 food groups (alcoholic beverages, cereal and cereal products, egg and egg dishes, fats and oils,
100 fish and fish products, fruit, meat and meat products, milk and milk products, non-alcoholic
101 beverages, nuts and seeds, potatoes, soups and sauces, sugars; preserves and snacks, and
102 vegetables) were reported in the present analysis.

103 The validated Patient Health Questionnaire: Somatic Anxiety and Depressive Symptoms (PHQ-
104 SADS) was used to determine the presence of symptoms related to a mental health condition ⁽²⁴⁾. It
105 combines three questionnaires to screen for the presence of depression (PHQ-9), anxiety (GAD-7)
106 and somatization (PHQ-15) disorders. Each part of the questionnaire resulted in a score from

107 which individuals are categorized as 'none', 'mild', 'moderate' or 'severe' with relation to the
108 presence of depressive, anxiety and/or somatic symptoms.

109 A 'Health and Lifestyle' questionnaire formulated specifically for the present study was used to
110 record demographic data as well as information about smoking, alcohol and substance abuse. The
111 questionnaire consisted predominantly of quantitative questions requiring a yes/no answer.
112 Individuals were also asked about their appetite, meal frequency and the amount of money spent
113 on food using questions, as per previous studies on nutritional status and homelessness ⁽⁷⁾.

114 *Physiological measurements*

115 A stadiometer (Seca 213, Seca medical measuring systems) and calibrated electrical scales
116 (Seca 877, Seca medical measuring systems) were used to measure height and weight
117 respectively using standard operating procedures. BMI was calculated as weight (kg)/ height (m²)
118 and classified in accordance with the WHO guidelines ⁽²⁵⁾. The mean of three handgrip strength
119 measurements of the participant's dominant hand using a hand-held dynamometer (Takei 5001,
120 Takei Scientific Instruments Co.) provided a non-invasive measure of general muscle strength ⁽²⁶⁾.
121 Blood pressure measurements were taken in triplicate using an automated blood pressure monitor
122 (M10-IT, Omron healthcare Ltd.). In order to assess CVD risk, the online 'QRISK 2-2015 Web
123 Calculator' was used to estimate the 10-year risk of developing CVD ⁽²⁷⁾.

124 *Statistical analysis*

125 The study was powered using previous comparison of energy intake (kJ) in homeless and
126 domiciled male youths in Toronto ⁽²⁸⁾. Using G*Power ⁽²⁹⁾, it was estimated that 68 participants
127 would be required in each group for a 2385kJ energy difference with s SD of 6408kJ (α level
128 $P=0.05$, $1-\beta$ power 0.85). Estimated samples sizes based on differences in total fat (g), protein (g),
129 vitamin B6 (mg) and calcium (mg) were lower (range $n=12-32$ per group). To allow for a 10%
130 dropout or incomplete data collection a total of 75 participants were recruited per group.

131 Means and standard deviations were used to describe parametric distributed data, and medians
132 and 95% Confidence Intervals (CI) for non-parametric distributed data. Counts and percentages
133 were used for categorical variables. Homeless and housed groups were broadly matched for their
134 gender, age range and ethnic category during the data collection stage. Data were checked for
135 normality of distribution, and where possible skewed variables were transformed using \log_{10} .

136 Parametric data were analysed using general linear models (GLM) and non-parametric using
137 Independent samples Mann-Whitney U tests for the comparison of continuous variables. For
138 categorical variables chi-squared tests were used to assess for differences between the two
139 groups. $P < 0.05$ was classified as significant. Data were analysed using SPSS Statistics 21.0 (IBM,
140 UK).

141

142 **Results**

143 *Participant characteristics*

144 Demographic information of the homeless ($n=75$) and housed ($n=75$) groups is shown in **Table**
145 **1**. The mean age was 38 (SD 11) years (range 19-59 years) for the homeless and 38 (SD 11)
146 years for the housed participants (range 20-59 years). Ethnicity and gender distributions were
147 matched between groups. With regards to education, there was a significant difference in
148 attainment between groups ($P < 0.001$); whilst the majority of homeless individuals had achieved
149 secondary education or lower education (O-Level's/GCSE's and primary education), the majority of
150 the housed group had attained above secondary level with 25% ($n=19$) reporting higher degrees
151 compared to 4% ($n=3$) in the homeless group. Homeless individuals consisted of those sleeping
152 rough on the street ($n=24$) or residing in Hamble Court ($n=22$) or Salvation Army ($n=29$) hostels. All
153 housed individuals lived in private sector accommodation consisting of rented, mortgaged or
154 owned property.

155 Responses of both groups to questions regarding reward mediated behaviour, meal
156 consumption and cooking facilities are shown in **Table 2**. Significantly more homeless compared to
157 housed individuals reported that they smoked ($P < 0.001$) and/or had taken illicit substances within
158 the preceding month ($P < 0.001$). There was no significant difference between the number of
159 individuals who reported consuming alcohol, although significantly more of the homeless (35%,
160 $n=18$) compared to housed (8%, $n=5$) individuals who consumed alcohol reported intakes above
161 the recommended weekly intake of 14 units (UK) for men and women respectively ($P < 0.001$, data
162 not shown). The majority of homeless individuals reported consuming 1 or 2 meals per day in
163 contrast to the housed that predominantly reported 3 meals daily ($P < 0.001$). In addition,
164 significantly less homeless participants reported having enough to eat, a good appetite and

165 cooking facilities (all comparisons, $P<0.001$). For the homeless individuals reporting cooking
166 facilities, the majority only had access to a microwave in a communal living space whereas all
167 housed participants reported a full kitchen in their accommodation. A greater proportion of
168 homeless individuals reported receiving less than £150 (\$200) and spending less than £50 (\$67)
169 on food per week compared to housed individuals (all comparisons, $P<0.001$).

170 *Physiological and psychological characteristics*

171 There was no significant difference in BMI between the two groups as shown in **Table 3**.
172 However, a greater number of homeless (66.6%) had a BMI $<24.9\text{kg/m}^2$, with 5.3% classified as
173 underweight (BMI $<18.5\text{m}^2$), whereas half (50.6%) of the housed group were classified as
174 overweight and obese (BMI $>25\text{kg/m}^2$) and none as underweight. Despite this 4% more homeless
175 adults (21.3% vs. 17.3% for housed) were also classified as obese (BMI $>30\text{kg/m}^2$). The homeless
176 had a significantly higher mean diastolic blood pressure (DBP) ($P=0.008$) and mean QRISK-2
177 score ($P=0.009$) compared to the housed, with no significant difference in systolic BP (SBP) or
178 handgrip strength.

179 Homeless individuals scored significantly higher than the housed group for the presence of
180 somatic (PHQ-15), anxiety (GAD-7) and depressive (PHQ-9) symptoms (all comparisons,
181 $P<0.001$) with a mean classification of 'mild' (score range 5-9) for each condition (**Table 3**). In total,
182 24% (n=18) of homeless adults reported mental illness diagnoses (depression, n=11;
183 schizophrenia, n=1, multiple diagnoses, n=5; undisclosed diagnosis, n=1) and 4% (n=3) of housed
184 adults (all depression).

185 When comparing street homeless (n=24) with first-stage living hostel residents (n=51), no
186 significant differences were observed for weight, BMI, SBP, DBP or PHQ-SADS scores (**Table 6**).
187 There was a trend for higher handgrip strength in street homeless participants compared to first-
188 stage living hostel residents ($P=0.058$), although the difference failed to reach significance. Mean
189 duration of street homelessness was 5.4 (SD 6.8) months and hostel residency 9 months (SD 9.3).

190 *Nutritional intake*

191 Homeless individuals reported a significantly higher mean daily intake of total fat ($P=0.049$),
192 SFA ($P=0.002$), MUFA ($P=0.026$) and alcohol ($P<0.001$), as a percentage of energy intakes,
193 compared to the housed group (**Table 4**). In contrast, carbohydrate ($P<0.001$) and protein

194 ($P=0.011$) accounted for a significantly lower percentage of energy in the homeless group. Mean
195 daily intake of non-starch polysaccharides (NSP) was significantly lower in homeless compared to
196 homed individuals ($P<0.001$). Further comparison of daily NSP intake with the UK recommended
197 level of 18g⁽³⁰⁾ highlighted that the majority of homeless ($n=58$, 77%) and homed ($n=46$, 61%)
198 individuals had an intake below 18g (data not shown). Removal of over-reporters ($n=2$, homeless
199 adults) did not alter the statistical findings (data not shown). Whilst total energy intake did not differ
200 between street homeless and hostel residents, mean SFA intake (%TE) was significantly higher for
201 hostel residents ($P=0.010$).

202 Micronutrient data (**Table 4**) demonstrated a significantly higher mean daily intake of salt in the
203 homeless compared to housed group ($P=0.014$). In contrast, vitamin C intake was significantly
204 lower in the homeless compared to housed ($P=<0.001$). Daily intake for the majority of individuals
205 in both the homeless and homed groups was found to meet or exceed the RNI (32) for most of the
206 micronutrients measured including vitamin C. In contrast, 58 (77%) homeless and 54 (72%) homed
207 individuals had below the LRNI for selenium (**Figure 1**). Approximately half of the homeless ($n=39$,
208 52%) and homed ($n=38$, 51%) groups failed to meet the zinc LRNI. Although the majority of
209 homeless ($n=40$, 53%) and homed ($n=41$, 55%) individuals met the iron LRNI, these were
210 predominantly men. Consequently for women, 13 out of 15 homeless and all of the 15 women in
211 the homed group failed to reach the iron LRNI of 14.8mg (data not shown). In contrast to iron, the
212 majority of homeless ($n=61$, 81%) and homed individuals ($n=67$, 89%) reported a sodium intake
213 above the LRNI of 1600mg. Of these individuals 45 (60%) homeless and 42 (56%) homed
214 consumed above the recommended maximum salt level of 6g.

215 Division of FFQ data into food groups is shown in **Table 5**. The mean daily homeless diet
216 consisted of significantly higher amounts of alcoholic beverages ($P<0.001$), fats/oils ($P=0.023$),
217 meat and meat products ($P=0.037$) and potatoes ($P=0.035$). In contrast, the homeless compared to
218 homed diet was composed of a significantly lower amount of fruit and nuts and seeds (P 's <0.001),
219 and vegetables ($P=0.022$). Removal of individuals reporting mental health diagnoses ($n=21$)
220 resulted in a loss of significant difference in intake of fats/oils ($P=0.18$) between the groups; no
221 other findings were altered.

222 Calcium, iodine and riboflavin intakes were all significantly lower in street homeless compared
223 with first-stage living hostel residents ($P<0.05$) (**Table 6**). Despite this, hostel residents were found
224 to consume significantly greater quantities of milk ($P=0.001$) and potato ($P=0.012$), and less soups
225 and sauces ($P=0.047$). There was also a trend for greater sugary snack consumption in hostel
226 residents ($P=0.052$).

227 As a sensitivity analysis, data analysis was repeated in males only ($n=120$) and in
228 participants reporting 'white' ethnicity ($n=122$). The identified significance differences were similar
229 following removal of females, although just a tendency for a lower vitamin B6 intake in the
230 homeless was observed ($P=0.078$). Analysis in only white participants led to an additional
231 significant difference for PUFA ($5.51\% \pm 1.41$ homeless, $5.91\% \pm 1.36$ housed, $P=0.031$).

232

233 **Discussion**

234 The present study compared dietary intake, nutritional status and mental wellbeing of homeless
235 and housed adults in Reading. Our findings suggest that homeless adults have a higher risk of
236 cardiovascular disease and incidence of anxiety and depressive symptoms, and poorer dietary and
237 nutrient intake than housed adults. Homeless diets were characterised by high consumption of
238 meat and meat product, fats and oils and alcoholic beverages, and significantly lower intakes of
239 fruits, vegetables, nuts and seed than housed comparators. Street homeless were at particular
240 risk of calcium and iodine deficiency, and had a significantly lower intake of milk and milk products
241 than hostel residents.

242 Whilst no significant difference in energy intake was observed between homeless and housed
243 adults, 27% of homeless reported not having 'enough to eat' and 38% reporting having \leq one
244 meals per day. There was also a trend ($P=0.080$) for a lower BMI in the homeless group. In the
245 present study, both homeless and housed intakes of total fat and SFA exceeded the UK
246 recommended intakes (total fat, 34% total energy; SFA, 10% total energy)⁽³⁰⁾. However, homeless
247 adults reported significantly a higher intake of these fats, as observed previously in the homeless
248 community^(7; 32). This may be attributed to their greater intakes of meat and meat products (e.g.
249 sausages, minced beef and processed sliced meat) and fats and oils (e.g. butter). SFA intake was

250 also significantly higher in hostel residents than street homeless, which supports previous data that
251 charitable meal provision is weighted towards sugar and fat energy ⁽³³⁾. Homeless adults reported a
252 significantly lower intake of carbohydrate and protein derived energy.

253 Englyst NSP intake was below the recommended daily intake of 18g/day ⁽³⁰⁾ in both housed
254 and homeless groups. However, significantly lower intakes of NSP were reported in the homeless
255 group (no difference between street homeless and first-stage living hostel residents), which may be
256 due to their lower fruit and vegetable intake. A diet low in fruit, vegetables and fibre has been
257 reported previously in the homeless community ⁽³⁻⁵⁾. In the present study, a greater disparity in fruit
258 intake between homeless and housed participants than vegetables was observed (170% vs.19%
259 higher in housed respectively); this may reflect the type of meals (hot meals including vegetables
260 ⁽³⁶⁾) available to the homeless population and lack of fresh fruit provided. In line with a low fruit
261 intake, a significantly lower intake of vitamin C was observed in the homeless, supporting previous
262 studies ^(6; 31). However the majority of homeless individuals still met or exceeded the daily vitamin C
263 RNI of 40mg.

264 Intakes of calcium, iodine and riboflavin were significantly lower in street homeless compared
265 with hostel residents, who consumed significantly more milk and milk products and potato. This
266 may be due to hostel residents having access to cold food storage facilities and regular cooked
267 meals, which has been associated with nutritional advantages in the US ⁽³⁵⁾. Inadequate calcium
268 intakes have been observed previously in UK single homeless adults⁽³⁶⁾.

269 Alcohol was a significant source of energy in the homeless group, as reported previously ⁽⁶⁾.
270 Furthermore, a greater percentage of homeless had B vitamin intakes below the LRNI and, given
271 that chronic alcohol use is associated with malabsorption and reduced utilization of B vitamins ⁽³⁸⁾,
272 this is likely to be underestimated. Early clinical thiamin (vitamin B1) deficiency, which causes the
273 alcohol-linked neurological disorder Wernicke–Korsakoff syndrome, has been observed previously
274 in homeless men ⁽³⁹⁾ and prophylactic oral thiamine is advised for harmful or dependent drinkers at
275 risk of malnutrition ⁽⁴⁰⁾.

276 The significantly higher salt intake in the present homeless population represents an
277 established risk factor for the development of hypertension ⁽⁴¹⁾ although, despite a significantly
278 higher diastolic level in the homeless group, mean blood pressure measurements were within the

279 normal range ⁽⁴²⁾. However, the significantly higher QRISK-2 score in the homeless group indicates
280 that the homeless group are at a greater risk of developing CVD within the next 10 years. Hand
281 grip strength, a low value of which has been associated with increased mortality in adults > 50
282 years ^(26; 43), was significantly greater in street-homeless compared to hostel residents; although
283 this is likely to be most reflective of increased physical activity. Significantly more homeless
284 compared to housed reported smoking and substance misuse in the present study, as documented
285 previously ^(4; 12). Furthermore, a significantly greater number of homeless that consumed alcohol
286 reported an intake above recommended levels, which is consistent with previous data ⁽⁶⁾.

287 Homeless adults had significantly higher scores for each PHQ-SADS component compared to
288 housed group, which corresponds with the high levels of mental illness reported in the homeless
289 community versus the general population ⁽¹²⁾. Within the homeless community, street sleepers are
290 more likely to experience depression ⁽⁴⁴⁾, as observed in the present study whereby street
291 homeless had higher scores for the depressive component (PHQ-9) of the PHQ-SADS compared
292 with hostel residents. It is currently unclear as to whether mental illness precedes homelessness or
293 homelessness induces/ exacerbates the occurrence of mental illness and the role, if any, nutrition
294 has to play in these conditions. The higher numbers of homeless compared to housed reporting a
295 poor appetite, in the presence of the increased levels of mental illness, may reflect the depressive
296 influence of mental conditions on appetite ⁽⁴⁵⁾, which warrants further investigation.

297 The current study has a number of limitations. The high male to female ratio is consistent
298 with other studies and reflects the preponderance of males in the homeless population ⁽¹²⁾.
299 However, male dominance and potential selection bias due to reliance on services accessed by
300 the homeless to attain participants limit the generalizability of the results ⁽⁴⁸⁾. In addition,
301 comparison with the most recent (2011) Census in Reading (74.8% white)⁽⁴⁹⁾, suggests that white
302 individuals may have been over-represented in this sample (81% white). The significant difference
303 between the educational status of the homeless and housed groups may represent an uncontrolled
304 confounding factor given that higher educational status has been associated with a 'healthier' diet
305 ⁽⁵⁰⁾. The EPIC FFQ has been validated for the assessment of nutrient intake in different populations
306 ^(22; 51), is less burdensome than weighed intake diaries and was consequently considered
307 appropriate for the current research. However, due to the transient nature of the homeless

308 population, participants were asked to report dietary intake over the previous month (i.e. shorter-
309 term intake), which may have been challenging individuals with fluid dietary patterns. Memory
310 recall may be further confounded in the homeless community whereby greater incidences of
311 reward mediated behaviour, mental illness and alcohol related brain damage are reported.
312 Objective assessment of energy expenditure, food intake and nutritional status, using biomarkers,
313 would help to confirm the observed differences. Finally, the grouping of hostels may be
314 confounding due to differences in storage facilities and the provision of food. For example, whilst
315 breakfast and dinner were provided by the charity-led hostel, residents in the council-led hostel
316 were self-catered. Further analysis regarding the impact of meal provision on nutritional status in
317 first-stage living hostels is therefore warranted.

318 The often limited and infrequent access to food by homeless individuals means that the
319 provision of nutritionally sufficient meals is of utmost importance. However, determining which
320 nutritional issues are specific to a homeless community is required in order to determine suitable
321 intervention strategies. Previous studies have aimed to address poor dietary intake in homeless
322 populations through recipe modification at food aid organisations ⁽³³⁾ and implementation of
323 educational programs ^(21; 32; 46). Decreasing the total and SFA content of meals and increasing fruit
324 availability in the hostels surveyed would help to address some of the issues identified in Reading.
325 Milk supplementation in street-homeless adults could also help to address calcium, iodine and
326 riboflavin insufficiencies. Whilst beyond the scope of this study, exploration of Food Bank usage,
327 which has increased in the UK ⁽⁴⁷⁾, may also assist in the identification of suitable interventions for
328 the local area.

329 The findings of this study highlight the vulnerability of homeless adults in Reading, who have
330 reduced mental wellbeing, a higher risk of CVD and a poorer dietary intake compared with the
331 housed population. Further objective data is warranted, but the results clearly highlight the need for
332 intervention aimed at improving mental wellbeing and nutritional status in this group.

333

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339

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343

344 **Conflict of Interest**

345 None

346

347 **Authorship**

348 JAL and RF designed the research protocol; RF, JS, CM and LA collected homeless data; JS
349 collected homed data; JS and RF analysed data and drafted the manuscript. All authors have read
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Table 1: Demographic characteristics of homeless (n=75) and housed (n=75) adults

Characteristics	Homeless		Housed	
	<i>n</i>	%	<i>n</i>	%
Gender				
Males	60	80	60	80
Females	15	20	15	20
Ethnicity				
White	61	81	61	81
Mixed	7	9	7	9
Indian/Pakistani/Bangladeshi	2	3	2	3
Black/African/Caribbean	5	7	5	7
Education				
Secondary education or below	64	85	12	16
Above secondary education	11	15	63	84
Housing status				
Living on the street	24	32	0	0
Living in a hostel	51	68	0	0
Living in private sector accommodation	0	0	75	100

Table 2: Responses by homeless (n=75) and housed (n=75) groups to behavioural questions¹

Behavioural questions	Subjects responding 'yes'				P value
	Homeless		Housed		
	n	%	n	%	
Do you smoke? ²	71	95	2	3	<0.001
Do you drink alcohol?	52	69	61	81	0.070
Do you take illicit drugs? ²	46	61	1	1	<0.001
Do you have enough to eat?	55	73	75	100	<0.001
Do you have a good appetite?	51	68	71	95	<0.001
Are there any cooking facilities available for use?	31	41	75	100	<0.001
How many meals do you have per day? ²					<0.001
0	2	2	0	0	
1	27	36	0	0	
2	35	47	21	28	
3	11	15	54	72	
How much money do you receive per week? ²					<0.001
<£50	23	31	0	0	
£50-£149	45	60	12	16	
>£150	7	9	63	84	
How much money do you use to buy food per week? ²					<0.001
<£20	53	70	4	5	
£20-49	20	27	37	49	
>£50	2	3	34	46	

¹Data were analysed using chi-square tests comparing homeless and housed responses on each characteristic

²Analysed using Fisher's Exact test with Freeman-Halton extension for contingency tables greater than 2x2

Table 3: Physiological characteristics, PHQ-9 SADS and QRISK-2 scores for homeless (n=75) and housed (n=75) adults¹

Characteristics	Homeless		Housed		P value
	Mean	SD	Mean	SD	
Weight, kg	73.3	15.4	77.5	14.6	0.19
Height, m	1.74	9.0	1.73	8.8	0.63
BMI, kg/m ²	24.5	5.7	25.8	4.2	0.08
Underweight (<18.49kg/m ² , %)	5.3		0.0		-
Healthy (18.5-24.9kg/m ² , %)	61.3		48.0		-
Overweight (25-29.9kg/m ² , %)	12.0		33.3		-
Obese (>30kg/m ² , %)	21.3		17.3		-
Systolic blood pressure, mm Hg	125.7	17.9	124.2	12.1	0.70
Diastolic blood pressure, mm Hg	78.2	12.0	73.6	8.2	0.008
Hand grip strength, kg	36.4	8.4	37.5	9.2	0.60
QRISK-2 Score (%) ²	5.1	6.2	2.7	4.0	0.009
GAD-7 ³	6.0	5.9, 9.1	2.5	1.7, 3.3	<0.001
PHQ-9 ³	7.0	7.3, 10.9	2.0	1.9, 3.3	<0.001
PHQ-15 ³	6.0	5.5, 7.7	3.0	2.7, 3.9	<0.001

¹Data were analysed using independent t-tests. PHQ-15, patient health questionnaire-15 for somatic symptoms; GAD-7, general anxiety disorders-7 for anxiety symptoms; PHQ-9, patient health questionnaire-9 for depressive symptoms.

²Estimated risk of developing CVD over the next 10 years.

³Values are medians (95% CI), data analysed using Independent samples Mann-Whitney U Test.

Table 4: FFQ derived daily energy and nutrient intake for homeless ($n=75$) and housed adults ($n=75$)¹

Nutrient	Homeless		Housed		<i>P</i> value
	Mean	SD	Mean	SD	
Energy, kcal	2140	1121	1848	471	0.38
Energy, kJ	8988	4700	7741	2016	0.39
Total fat, % TE	37.2	6.3	34.9	5.3	0.049
SFA, % TE	14.6	3.1	13.0	3.3	0.002
MUFA, % TE	13.9	2.6	13.0	2.2	0.026
PUFA, % TE	5.5	1.4	5.9	1.4	0.08
Cholesterol, mg	357	204	274	114	0.020
Total protein, % TE	16.7	4.0	18.2	3.5	0.011
Total carbohydrate, % TE	43.4	9.3	48.1	6.9	<0.001
Total Sugars, %TE	5.4	2.6	4.4	1.2	0.009
Englyst Fibre (NSP), g	13.4	7.9	16.3	6.4	<0.001
Alcohol, g	17.5	30.7	5.0	8.1	<0.001
Alcohol, % TE	5.3	7.7	1.9	2.6	<0.001
Calcium, mg	977	537	942	323	0.77
Iron, mg	11.0	6.1	10.9	3.0	0.18
Total folate, mcg	288	173	281	92	0.25
Iodine, mcg	148	78	146	44	0.35
Sodium, mg	3186	1974	2573	764	0.17
Salt, g	8.0	4.9	6.4	1.9	0.014
Niacin, mg	22.8	11.9	22.5	6.0	0.21
Selenium, mcg	60.7	42.0	61.2	19.2	0.083
Vitamin A, mcg	1491	2107	1122	1252	0.85
Thiamin, mg	1.5	0.8	1.5	0.4	0.24
Riboflavin, mg	2.2	1.4	2.0	0.7	0.90
Vitamin B6, mg	2.1	1.0	2.2	0.6	0.032
Vitamin B12, mcg	8.4	9.1	6.4	4.5	0.58
Vitamin C, mg	78.8	58.9	109.4	62.5	<0.001
Vitamin D, mcg	3.5	3.6	3.0	1.7	0.74
Vitamin E, mg	12.1	7.0	11.8	4.2	0.34
Zinc, mg	9.7	4.9	9.3	2.4	0.53

¹Values are means \pm SDs, homeless ($n=75$) and housed ($n=75$). Data were analysed using independent t-tests. NSP, non-starch polysaccharide; %TE, percentage of total energy intake.

Table 5: Daily intake of the 14 food groups derived from FFQ analysis for homeless (n=75) and housed (n=75) adults¹

Food group	Homeless		Housed		P value
	Mean	SD	Mean	SD	
Alcoholic beverages, g	363	593	93.5	185	<0.001
Cereals and cereal products, g	235	178	240	109	0.076
Eggs and egg dishes, g	20.6	21.2	19.0	17.9	0.61
Fats and oils, g	23.6	20.5	16.0	11.2	0.023
Fish and fish products, g	41.2	63.7	40.3	27.8	0.052
Fruit, g	96	107	260	224	<0.001
Meat and meat products, g	157	109	111	54	0.037
Milk and milk products, g	400	241	385	198	0.80
Non-alcoholic beverages, g	790	710	710	438	0.83
Nuts and seeds, g	3.4	7.4	9.9	15.0	<0.001
Potatoes, g	94.0	67.0	66.3	50.3	0.035
Soups and sauces, g	61.4	61.1	56.1	55.3	0.76
Sugars; preserves and snacks, g	43.3	46.4	39.6	32.0	0.96
Vegetables, g	205	156	244	149	0.022

¹Data analysed using GLM.

Table 6: Subject characteristics and nutritional intake for street homeless (n=24) and first-stage living hostel residents (n=51)¹

Characteristic	Street homeless		Hostel residents		P-value
	Mean	SD	Mean	SD	
Gender (m/f)	21/3	-	39/12	-	-
Age, years	38	11	38	11	0.99
Weight, kg	74.7	16.0	73.9	16.7	0.78
BMI, kg/m ²	23.9	4.6	25.1	6.3	0.42
SBP	130.1	17.1	123.9	17.7	0.15
DBP	81.4	9.5	76.9	12.6	0.096
Hand-grip	39.7	8.2	35.3	8.3	0.058
GAD-7 ²	6.0	5.1, 12.6	6.0	5.3, 8.4	0.84
PHQ-9 ²	8.0	7.2, 15.2	7.0	6.2, 10.1	0.27
PHQ-15 ²	6.0	4.8, 9.9	6.0	5.2, 7.4	0.83
Energy, kcal	2008	1388	2202	979	0.13
Energy, kJ	8428	5814	9251	4114	0.13
Fat, %TE	36.6	7.0	37.5	6.0	0.55
SFA, %TE	13.7	3.1	15.0	3.1	0.010
MUFA, %TE	14.0	2.9	13.8	2.5	0.86
PUFA, %TE	5.7	1.6	5.4	1.3	0.56
Protein, %TE	17.1	5.0	16.6	3.5	0.89
CHO, %TE	41.5	11.2	44.5	8.2	0.19
Sugars, g	94.1	60.8	121.8	70.3	0.15
NSP, g	13.2	9.5	13.5	7.2	0.39
Alcohol, g	23.9	40.2	14.5	25.0	0.39
Calcium, mg	858	707	1032	433	0.027
Iron, mg	10.8	7.8	11.0	5.3	0.41
Total folate, mcg	226	167	304	174	0.10
Iodine, mcg	128	91	157	73	0.033
Sodium, mg	3198	2531	3180	1680	0.42
Salt, g	8.0	6.3	7.9	4.2	0.41
Niacin, mg	22.3	13.8	23.0	11.0	0.43
Selenium, mcg	62.3	49.8	59.9	38.2	0.63
Vitamin A, mcg	1252	1647	1604	1647	0.18
Thiamin, mg	1.34	0.86	1.55	0.84	0.10
Riboflavin, mg	1.79	1.22	2.42	1.45	0.012
Vitamin B6, mg	1.89	1.13	2.20	0.99	0.10
Vitamin B12, mcg	7.3	7.5	9.0	9.8	0.13
Vitamin C, mg	74.6	65.3	80.8	56.2	0.23
Vitamin D, mcg	3.2	2.6	3.7	4.0	0.22
Vitamin E, mg	11.4	7.8	12.4	6.6	0.25
Zinc, mg	9.6	6.4	9.8	4.2	0.35
Cereal and cereal products (g/day)	229	225	238	154	0.22
Egg and egg dishes (g/day)	17.4	16.4	22.1	23.1	0.36

Fats and oils (g/day)	22.1	23.8	24.4	19.0	0.16
Fish and fish products (g/day)	30.4	30.3	46.4	74.1	0.16
Fruit (g/day)	97	131	95	96	0.87
Meat and meat products (g/day)	164	137	153	95	0.40
Milk and milk products (g/day)	295	226	449	234	0.001
Nuts & seeds (g/day)	5.2	9.3	2.5	6.2	0.08
Potato (g/day)	66.6	43.5	107.4	72.1	0.012
Soups and sauces (g/day)	90.4	78.7	47.7	45.6	0.047
Sugars; preserves and snacks (g/day)	30.8	26.2	49.2	52.5	0.052
Vegetables (g/day)	205	162	205	155	0.71

¹Values are means \pm SDs, street homeless ($n=24$) and hostel residents ($n=51$). Data were analysed using GLM. NSP, non-starch polysaccharide; %TE, percentage of total energy intake.

²Data are medians (95% CI), analysed using Independent Samples Mann-Whitney U Tests.

Figure 1: Homeless and housed individuals with daily intake below LRNI for each micronutrient. Values are percentages (%) of individuals who did not meet the daily RNI for each micronutrient, homeless ($n=75$) and housed ($n=75$)