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## Review Paper

## A systematic review of the nutritional status of adults experiencing homelessness

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## ABSTRACT

**Objectives:** To identify, appraise, and describe studies focussing on the nutritional characteristics of people experiencing homelessness (PEH).**Study design:** Systematic (narrative) review.**Methods:** We identified full-text studies of any design and in the English language of adults ( $\geq 18$  years) fulfilling the European Typology criteria for homelessness, based in community or hospital settings, and which report nutritional measures. Five electronic databases, 13 grey literature sources, reference lists, and forward citations were searched. Data on study characteristics and nutrition measures were collected and synthesised narratively. Risk of bias was assessed using relevant checklists for each study type.**Results:** A total of 1130 studies were identified and retrieved. After screening, six studies were included for review: three cross-sectional studies; two case–control studies; and one randomised control trial, involving a total of 1561 participants from various settings including shelters, drop-in centres, hospitals, and hostels. All included studies were from high-income countries. Studies reported a range of nutrition measures including anthropometry (e.g., body mass index (BMI)), serum micronutrients and biomarkers, and dietary intake. Between 33.3% and 68.3% of participants were overweight or obese; 3.5%–17% were underweight; and low blood levels of iron, folate, vitamins C, D, and B12, and haemoglobin were prevalent. PEH consumed high amounts of dietary fats and alcohol, and low amounts of fruits and vegetables compared with national guidelines and housed individuals. There was moderate to high risk of selection and measurement bias and confounding in included studies.**Conclusions:** A majority of PEH are within unhealthy BMI ranges and are deficient in serum micronutrients and nutritional biomarkers. Studies using large data sets that examine multiple aspects of nutrition are needed to describe the nutritional characteristics of PEH.**Registration:** This systematic review is based on a prespecified protocol registered with the International Prospective Register of Systematic Reviews (PROSPERO CRD42021218900).© 2022 The Author(s). Published by Elsevier Ltd on behalf of The Royal Society for Public Health. This is an open access article under the CC BY license (<http://creativecommons.org/licenses/by/4.0/>).

## Background

Adult malnutrition is a major global health problem. Worldwide, it is estimated that 1.9 billion adults are overweight or obese and 462 million are underweight.<sup>1</sup> Diet is a significant contributor to the

global burden of non-communicable disease (NCD) with 255 million disability-adjusted life years attributable to dietary factors.<sup>2</sup> Malnutrition is characterised by undernutrition (wasting, stunting, and underweight); micronutrient malnutrition (lack or excess of essential vitamins and minerals); and overweight, obesity, and diet-related NCDs such as cardiovascular disease, diabetes, and cancer.<sup>3</sup> Malnutrition increases vulnerability to illness and death via several mechanisms: by impairing the immune system, worsening infections and delaying recovery from illness; by reducing muscle strength and increasing fatigue, hindering activities of daily

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living (e.g., work, self-care); and by reducing psychosocial function.<sup>4</sup>

Malnutrition is spread unequally in populations and poverty heightens the risk of malnutrition. Those with low income and high food insecurity are more likely to consume energy-dense foods high in fat and sugar which, in high-income countries, are often cheaper and more readily available than healthier foods.<sup>5</sup> Conversely, nutrient-dense foods such as fruit, vegetables, low-fat milk, and wholemeal products tend to be less prevalent in the diets of those affected by poverty.<sup>3,6,7</sup> People experiencing homelessness (PEH) are particularly vulnerable to malnutrition because of a confluence of health and social factors. Homelessness can include several living conditions including a lack of shelter, sleeping rough, sleeping in temporary shelters, and having insecure or inadequate housing.<sup>8</sup> Compared with the general population, PEH are two to three times more likely to have chest, skin, and digestive problems, and are nearly twice as likely to have a diagnosed mental health problem.<sup>9,10</sup> A high proportion of PEH suffer from multimorbidity with an estimated median of six or seven long-term conditions, including physical and mental health problems and substance misuse.<sup>11</sup> This greater burden of poor health can deprioritise healthy eating, while poor nutrition exacerbates and contributes to the development of poor health.<sup>6</sup> The increased prevalence of health problems imposes greater nutritional requirements on PEH as energy and nutrient demands are higher during recovery from acute illness and whilst living with NCDs.<sup>12</sup> Drug and alcohol problems disproportionately affect PEH and pose further challenges to adequate nutrition, for instance, by impairing absorption of dietary nutrients and by reducing PEH's ability to engage with food services.<sup>13</sup> Moreover, a lack of fixed accommodation limits access to storage and cooking facilities and destitution leads to reliance on meals provided by shelters and soup kitchens, thereby limiting food choice.<sup>6</sup>

Despite widespread awareness of the challenging circumstances in which PEH live and the likely impact of inadequate nutrition, the literature assessing the nutritional status of this population remains sparse. To the best of our knowledge, there have been four literature reviews describing the nutritional characteristics of adult PEH.<sup>13–16</sup> Of these, two are systematic reviews focusing specifically on PEH with problem alcohol use; one of which describes nutritional deficiencies,<sup>14</sup> while the other examines interventions for preventing or treating malnutrition.<sup>15</sup> Although a large proportion of PEH are reported to have alcohol problems,<sup>17</sup> the focus on 'problem-drinkers' limits the generalisability of findings to the general adult population of PEH with associated over or under-estimation of specific nutritional deficiencies. Of the remaining two reviews, one lacked a prespecified protocol,<sup>16</sup> the other lacked systematic and comprehensive searches,<sup>13</sup> and neither had transparent data synthesis. One of these reviews described the nutritional requirements and eating patterns of PEH in USA<sup>13</sup> and the other described the methods and limitations of previous research on the nutrition of adult PEH.<sup>16</sup> Both found inadequate nutritional intake in PEH, but the reported nutritional deficiencies varied between studies because of methodological heterogeneity and variations in endogenous diets, cultures, and food processing (e.g., flour fortification) across countries. However, vitamin C deficiency was a common finding and the overall importance of diet as a risk factor for acute and chronic disease was highlighted in both studies.<sup>13,16</sup> In addition, one review found that studies of PEH reporting measures of skin-fold thickness and muscle mass frequently identified 'wasting' but acknowledged that other studies reported higher proportions of PEH were overweight or obese than underweight.<sup>16</sup>

To the best of our knowledge, there are no previous systematic reviews of studies describing the nutritional characteristics of unselected adult PEH. We, therefore, aimed to systematically identify, appraise, and synthesise studies that describe the nutritional characteristics of the general adult population experiencing homelessness.

## Methods

A prespecified protocol for this systematic review is registered with the International Prospective Register of Systematic Reviews (PROSPERO CRD42021218900).

### Eligibility criteria

Inclusion criteria followed a 'Population, Exposure, Comparator, and Outcome' framework approach.<sup>18</sup> We included studies of adults (aged  $\geq 18$  years) experiencing homelessness from any setting, e.g., community or hospital. We used the European Typology of Homelessness and Housing Exclusion (ETHOS) criteria to define homelessness as the exposure: 'rooflessness (without a shelter of any kind, sleeping rough); houselessness (with a place to sleep but temporary in institutions or shelter); living in insecure housing (threatened with severe exclusion due to insecure tenancies, eviction, domestic violence); living in inadequate housing (in caravans on illegal campsites, in unfit housing, in extreme overcrowding)'.<sup>8</sup> We collected all available and relevant data for within-study comparators, e.g., normal reference ranges rather than applying a single comparator to all studies because reference ranges and dietary guidelines vary. Eligible outcomes were any objective or quantitative measure of nutrition, including but not limited to: levels of serum micronutrients or biomarkers (e.g., vitamins, iron, calcium, full blood count, haemoglobin, albumin); dietary intake (e.g., proteins, fats, carbohydrates, fruit and vegetables); and anthropometric data (e.g., body mass index (BMI)). We included studies of any quantitative design (e.g., descriptive studies, cross-sectional studies, and randomised controlled trials) conducted in any country. Searches were limited to the English language. For pragmatic reasons, we adapted our protocol to only include studies with a clear focus on nutritional characteristics and excluded literature reviews. To build on previous evidence and capture the most recent literature, the date limits for our search strategy were from the last review in 2014–2021.<sup>16</sup> Exclusion criteria comprised studies of incarcerated individuals and PEH due to extreme circumstances (e.g., earthquakes or tsunamis); and studies that examined nutritional content of meals offered to PEH rather than nutritional characteristics of PEH themselves.

### Literature searches and study selection

Five electronic databases were searched from 1st January 2014 to 26th January 2021 (MEDLINE; Embase; PsycINFO; CINAHL; and Cochrane Central Register of Controlled Trials (CENTRAL)). The search strategy was adapted for each database and developed with input from a specialist librarian (CD) and a dietitian (MW). [Table 1](#) shows the full search strategy for MEDLINE. Strategies for the remaining databases can be found in [Supplementary Tables 1–4](#).

Thirteen grey literature sources were searched by a fourth reviewer (VP) in April 2021 using the following sources and strategies:

**Table 1**  
MEDLINE Search Strategy 1st Jan 2014 to 1st Jan 2021.

Search Terms	
1. Homeless person*.ti.	35. (nutri* adj intake).tw.
2. Home?less*.ti.	36. (nutri* adj biomarker*).tw.
3. roof?less.ti.	37. (nutri* adj deficient*).tw.
4. House?less.ti.	38. (nutri* adj screening).tw.
5. (Home* adj2 lack).ti.	39. (nutri* adj characteristic*).tw.
6. (Home* adj2 no).ti.	40. body mass index/
7. (without adj2 home*).ti.	41. Anthropometry/
8. (lack adj2 hous*).ti.	42. anthropometric measurement*.tw.
9. (no adj2 hous*).ti.	43. calories.tw.
10. (without adj2 hous*).ti.	44. protein*.tw.
11. (lack adj2 roof*).ti.	45. (calor* adj intake).tw.
12. (no adj2 roof*).ti.	46. malnutrition/or deficiency diseases/or severe acute malnutrition/or starvation/
13. (without adj2 roof*).ti.	47. (disease adj related adj maln*).tw.
14. (inadequate* adj3 hous*).ti.	48. exp Nutrition Surveys/
15. (insecure* adj3 hous*).ti.	49. exp Blood Cell Count/
16. (insecure* adj3 tenan*).ti.	50. Full blood count.tw.
17. (unfit* adj2 hous*).ti.	51. folate.tw.
18. ((transition* or insecure or inadequate or substandard or sheltered or emergency or intermittent or transient or marginal* or problem*) adj (hous* or home* or accommodat*).ti.	52. Vitamin B 12/
19. (sheltered or unsheltered or shelters).ti.	53. Vitamin B 12 Deficiency/
20. vagran*.ti.	54. Vitamin D/or Vitamin D Deficiency/
21. Destitute.ti.	55. Magnesium/or Magnesium Deficiency/
22. Skid?row.ti.	56. Iron, Dietary/or Iron/or Anemia, Iron-Deficiency/
23. (sleep* adj2 rough).ti.	57. C-Reactive Protein/
24. ("street person" or "street people").ti.	58. Calcium/or corrected calcium.tw.
25. unhoused.ti.	59. hand grip test.tw.
26. 1 or 2 or 3 or 4 or 5 or 6 or 7 or 8 or 9 or 10 or 11 or 12 or 13 or 14 or 15 or 16 or 17 or 18 or 19 or 20 or 21 or 22 or 23 or 24 or 25	60. 27 or 28 or 29 or 30 or 31 or 32 or 33 or 34 or 35 or 36 or 37 or 38 or 39 or 40 or 41 or 42 or 43 or 44 or 45 or 46 or 47 or 48 or 49 or 50 or 51 or 52 or 53 or 54 or 55 or 56 or 57 or 58 or 59
27. nutrition assessment.tw.	61. 26 and 60
28. (nutri* adj stat*).tw.	62. limit 61 to (English language and humans)
29. diet/or energy intake/or fasting/or food preferences/or exp hunger/or nutritional requirements/or nutritional status/or nutritive value/	63. limit 62 to "all child (0–18 years)"
30. exp malnutrition/	64. 62 not 63
31. ?nourish*.tw.	65. limit 62 to "all adult (19 plus years)"
32. undernourish*.tw.	66. 64 or 65
33. malnourish*.tw.	
34. nutrients/or micronutrients/or trace elements/or vitamins/	

- KHP Pathway, Shelter Scotland, Crisis, Homeless Link, Revolving Doors Agency, and Lankelly Chase were searched using the term 'nutrition'.
- King's Fund, Grey Guide, GOV.UK, and Google Scholar were searched with the terms 'homeless; nutrition' — the first 100 outputs were screened for relevance.
- Open DOAR was explored but did not permit article searches.
- The British Dietetic Association and the American Dietetic Association were searched with the term 'homeless'.

Duplicates were removed and the remaining references were uploaded to DistillerSR software. All titles and abstracts and then selected and full texts were screened independently by two reviewers (HF and CH). Conflicts at title and abstract stage were resolved by discussion or full-text articles were screened if eligibility was unclear. Discrepancies at full-text stage were resolved by discussion or by involving a third reviewer (RL). During full-text screening, CH identified reviews with a focus on the nutritional status of PEH and searched the citations of reviews to identify additional articles.

#### Data extraction

Data extracted included: first author; publication year; location; study design; participant characteristics (age, sex, ethnicity);

details of any comparators; definition of homelessness; and details of all nutritional characteristics reported and their results.

#### Risk of bias

Risk of bias (RoB) was assessed by CH using relevant tools for each study design: revised Cochrane risk of bias tool for randomised trials (RoB-2);<sup>19</sup> Critical Appraisal Skills Programme (CASP) case-control study checklist;<sup>20</sup> and the Joanna Briggs Institute (JBI) checklist for analytical cross-sectional studies.<sup>21</sup> Minor adaptations were made to the RoB tools to simplify their interpretation and provide overall scores (see [Supplementary material](#)). Studies that achieved 25–49%, 50–74%, and ≥75% of available points were classified as high, moderate, and low RoB, respectively.

#### Data synthesis

Studies were highly heterogeneous with respect to participants, methods, and outcomes. Therefore, meta-analysis was not appropriate and a narrative synthesis was conducted. Study findings were grouped and synthesised by type of nutritional data: anthropometric, micronutrient, and dietary intake.

## Results

### Study selection

The study selection process and reasons for exclusion at full-text level are shown in the PRISMA flowchart (Fig. 1). One thousand thirty studies were identified through electronic databases and 100 citations from grey literature. Six studies were included for review.

### Study characteristics

Characteristics of included studies are listed in Table 2. There were two studies from UK,<sup>22,23</sup> two from South Korea,<sup>24,25</sup> one from Canada,<sup>26</sup> and one from USA.<sup>27</sup> Three were cross-sectional studies,<sup>22,23,27</sup> two were case-control studies,<sup>24,25</sup> and one was a randomised control trial (RCT).<sup>26</sup> Participants were recruited from a variety of settings and sample sizes ranged from 75 to 575 participants. Most participants were men (64–95%).

### Risk of bias

Four studies included in this review had moderate RoB: three scored 50%<sup>23,24,27</sup> and one scored 60%.<sup>26</sup> One study had a high RoB (30%)<sup>25</sup> and one study had a low RoB (75%).<sup>22</sup> Sources of bias were similar across the studies with selection bias, measurement bias and potential effect of confounders being the primary contributors.

### Study findings

Studies reported three broad categories of nutritional data: anthropometry, serum micronutrient levels, and dietary intake.

### Anthropometry

Four studies<sup>22,23,26,27</sup> reported anthropometric data (Table 3). All four studies found high proportions of participants had an unhealthy BMI: 33.3–68.3% of participants were 'overweight or obese'

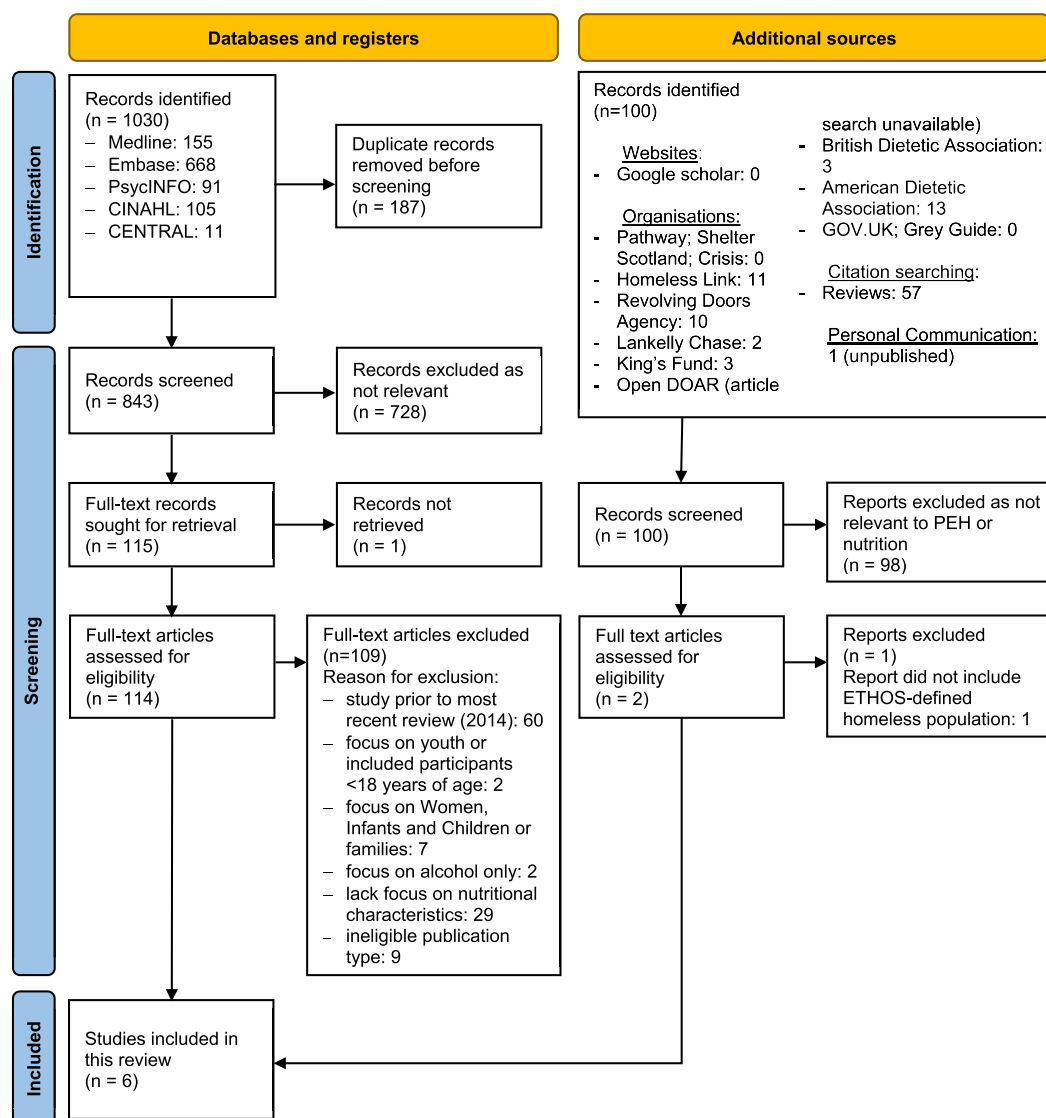


Fig. 1. PRISMA flowchart.

**Table 2**  
Characteristics of included studies.

Study	Design	City, Country	Homelessness definition (study population)	Setting	N	Age, years	% Female	Ethnicity	Nutrition data reported
W-Melnik et al. 2015 <sup>26</sup>	RCT	Toronto, Canada	Absolutely homeless <sup>a</sup> or precariously housed <sup>b</sup> (PEH with serious mental illness)	Shelters, drop-in centres, hospitals, outreach programs, mental health services, community centres	575	39.9 <sup>c</sup> (11.8)	30.0	52.9% Minority ethnic groups 4.7% Aboriginal 42.4% White	BMI, Waist circumference
Hui Jai Lee et al. 2015 <sup>24</sup>	Case-control	Seoul, South Korea	Not defined (PEH with acute alcohol intoxication)	Emergency room	217	51 (44.56)	4.1	Not reported	Serum biomarkers
Martins et al. 2015 <sup>27</sup>	Cross-sectional	Rhode Island, USA	Not defined (PEH)	Local service for PEH	319	18–65 <sup>d</sup>	36.0	47% White 20% African American 16% Hispanic, Latino 9% Mixed 5% Native American 1% Asian Pacific Islander 2% other	Weight, Height, BMI, Waist circumference
Fallaize et al. 2017 <sup>22</sup>	Cross-sectional	Reading, UK	'Living rough' or in supported accommodation (PEH, and housed control group)	Drop-in centre or hostel	75 (+75 housed)	38 (11)	20.0	81% White 7% Black, African, Caribbean 3% Indian, Pakistani, Bangladeshi 9% Mixed	Food frequency questionnaire, BMI, Handgrip
Philipson et al. 2018 <sup>23</sup>	Cross-sectional	Glasgow, UK	Registered with service for PEH (PEH)	Local service for PEH	196	40.8 ± 10.1	18.9	Not reported	Weight, BMI
Hui Jai Lee et al. 2019 <sup>25</sup>	Case-control	Seoul, South Korea	Not defined (PEH and national survey data as control)	Emergency room	179	52 (47–58)	5.0	Not reported	Serum biomarkers

PEH, people experiencing homelessness; Age given in mean (±SD) or median (IQR); RCT, randomised control trial; BMI, body mass index.

<sup>a</sup> 'No fixed place to stay for at least the past seven nights with little likelihood of finding a place in the upcoming month'.

<sup>b</sup> 'Housed in single room occupancy, rooming house, or hotel/motel as a primary residence and in the past year have a history of two or more episodes of being absolutely homeless or one episode of being absolutely homeless of at least 4 weeks duration in the past year'.<sup>28</sup>

<sup>c</sup> Average of 'moderate' and 'high' care groups.

<sup>d</sup> Age range, average not reported.



**Table 3**  
Anthropometric measures.

Study	Weight, kg	Height, m	BMI, kg/m <sup>2</sup>	Waist circumference, cm	Handgrip, kg
W-Melnik et al. 2015 <sup>26</sup>	—	—	26.4 ± 6.0 <sup>a</sup>	93.0 ± 15.3 <sup>a</sup>	—
Martins et al. 2015 <sup>27</sup>	84.5 ± 23.3	1.70 ± 10.3	29.5 ± 7.8	97.5 ± 17.6	—
Fallaize et al. 2017 <sup>22</sup>	73.3 ± 15.4	1.74 ± 9.0	24.5 ± 5.7	—	36.4 ± 8.4
Philipson et al. 2018 <sup>23</sup>	71.4 ± 15.6	—	24.4 ± 5.1	—	—

<sup>a</sup> Baseline mean and SD for 'moderate and high need' groups were combined using Cochrane's formulae for combined mean and SD.<sup>30</sup> — not reported.

**Table 4**  
Median (IQR) serum nutrient levels of PEH.

Study	Median serum nutrient levels (IQR)			
	Vitamins		Other	
Lee et al. 2015 <sup>24</sup>	B1	145.8 nM/l (108.5–197.7)	Haemoglobin	14 g/dl (12.4–15.3)
	B6	34.2 nM/l (20.5–65.5)		
	B12	617 pg/ml (458–918)		
	C	11.6 µM/l (3.7–21.6)		
	D	14.2 ng/ml (10.7–19.6)		
Lee et al. 2019 <sup>25</sup>	B1	151 mmol/l (116–205)	Haemoglobin Albumin Calcium	13.8 g/dl (12.5–15.1) 4.0 g/dl (3.7–4.2) 8.7 mg/dl (8.4–9.1)
	B6	34.1 mmol/l (22.1–53.3)		
	B12	572 pg/ml (392–804)		
	C	4.1 µmol/l (1.5–12.7)		
	D	14.2 ng/ml (10.7–19.6)		

<sup>a</sup> Hospital laboratory reference ranges.

(BMI >25 kg/m<sup>2</sup>) and 3.5–17% were underweight (BMI <18.5 kg/m<sup>2</sup>). Waist circumference (WC) was reported in two studies.<sup>26,27</sup> In one study, 74 (30.9%) PEH participants were classified as 'overweight or obese' (≥102 cm for men or ≥88 cm for women) with a combined mean WC for both men and women of 93.0 (±15.3) cm.<sup>26</sup> The remaining study reported a mean WC of 97.5 cm (SD 17.6) in 313 PEH but the number of participants classified as overweight or obese by WC was not reported.<sup>27</sup>

In the only included RCT,<sup>26</sup> the authors examined the effect of a housing intervention on BMI and WC. At baseline, 121 of 245 (49%) and 74 of 239 (30%) of all participants were overweight/obese as measured by BMI and WC, respectively. Proportions of overweight/obese at 24 months follow-up were statistically significantly increased in both treatment and control groups: 137 of 245 (56%) and 88 of 239 (37%), respectively. However, there was no evidence of improvement in BMI or WC between the intervention and control group.

Handgrip strength, an anthropometric marker of nutritional status,<sup>29</sup> was reported in one study.<sup>22</sup> The results showed slightly lower mean handgrip strength in PEH (36.4 ± 8.4 kg) compared with housed participants (37.5 ± 9.2 kg).

#### Serum micronutrients and biomarkers

Three studies reported serum micronutrient and nutritional biomarker levels.<sup>23–25</sup> Data from 122 PEH registered with Glasgow's specialist Homelessness Health Service, showed 41 (33.6%) were anaemic, of whom 21 had additional blood tests to investigate the anaemia and the following were found to be deficient in eight participants: iron (*n* = 1), vitamin B12 (*n* = 1), and folate (*n* = 6).<sup>23</sup> A study from South Korea compared levels of vitamins B1, B6, B12, and C with hospital reference ranges in 217 PEH with acute alcohol intoxication (Table 4).<sup>24</sup> Median levels were within the normal ranges for all vitamins except vitamin C where 183 (84.3%)

participants had low levels. Other abnormalities included five (2.3%), 51 (23.5%), and five (2.3%) participants with low levels of vitamins B1, B6, and B12, respectively. A retrospective chart review of 179 PEH from an emergency department in South Korea assessed vitamin D levels.<sup>25</sup> Using a nation-wide survey as a control, vitamin D deficiency was common generally, but PEH had lower vitamin D levels (15.7 ± 7.4 ng/ml vs 18.2 ± 5.5 ng/ml, *P* < 0.001) and higher proportions had severe vitamin D deficiency (18% vs 7.1%) (Table 4). Furthermore, vitamin D deficient participants had lower haemoglobin levels. Levels of vitamins B1, B6, B12, C, D, haemoglobin, albumin, and calcium were also reported but the absence of reference ranges precluded further comparisons.

#### Dietary intake

One study used a food frequency questionnaire to estimate daily intake of energy, macronutrients (carbohydrate, protein, and fat), key vitamins and minerals (vitamins A, B1, B2, B6, B12, C, D, E, iron, folate, calcium, iodine, zinc, and selenium), and food groups from PEH (*n* = 75) and a matched housed comparison group (*n* = 75).<sup>22</sup> A summary of these findings can be found in Supplementary Table 5. In general, the mean values for the intake of vitamins and minerals in PEH participants were similar to those of their housed counterparts except vitamin C intake, which was significantly lower in PEH (78.8 ± 58.9 mg vs 109.4 ± 62.5). However, compared to housed participants, salt, fat, and sugar intakes were significantly higher and carbohydrate and protein intake was significantly lower in PEH while there was limited evidence of any difference in total energy intake. There was greater variability across most nutrient levels in the PEH group, indicating greater variation in dietary intake in PEH compared with housed participants.

In the same study but examining main food groups, PEH consumed significantly higher amounts of alcohol (363 g (SD 593) vs 93.5 g (SD 185)), fats and oils (23.6 g (SD 20.5) vs 16.0 g (SD 11.2)),

meat (157 g (SD 109) vs 111 g (SD 54)), potatoes (94.0 g (SD 67.0) vs 66.3 (SD 50.3)); and significantly less fruit (96 g (SD 107) vs 260 g (SD 24)), nuts and seeds (3.4 g (SD 7.4) vs 9.9 g (SD 15.0)), and vegetables (205 g (SD 156) vs 244 g (SD 149)) than housed participants.

Similar results were found using 24-h dietary recall in a cross-sectional study of PEH ( $n = 197$ ) in Rhode Island, USA.<sup>27</sup> PEH reported higher mean daily servings of grains (7.9 vs 6.0) and fats (74.0 vs 6.0); and lower mean daily servings of vegetables (2.8 vs 5.0), fruits (1.3 vs 4.0), dairy (1.1 vs 3.0), and meats and beans (2.2 vs 5.5) compared with national dietary recommendations.

## Discussion

### Summary of findings

Six studies met our inclusion criteria and described the nutritional characteristics of PEH. Their methods and quality varied and sample sizes were small. However, of studies that reported BMI, all consistently reported high proportions of PEH with unhealthy BMIs (overweight/obesity and underweight).<sup>22,23,26,27</sup> Vitamin C deficiency was highly prevalent in a group of PEH with acute alcohol intoxication.<sup>24</sup> While vitamin D deficiency appeared to be more prevalent in PEH attending hospital than in healthy controls.<sup>25</sup> Deficiencies in iron, folate, and vitamin B12 were also found in conjunction with low haemoglobin in PEH.<sup>23</sup> However, these micronutrient and vitamin deficiencies were seen in single studies only. PEH were found to consume higher amounts of dietary fats and lower amounts of fruits and vegetables when compared with both a housed comparator group<sup>22</sup> and national recommendations.<sup>27</sup>

Anthropometric characteristics reported in the Glasgow-based study<sup>23</sup> were comparable to those of another UK study<sup>22</sup> with similar proportions of participants found in overweight or obese BMI categories (33% and 37%), while studies carried out in North America<sup>26,27</sup> reported higher proportions of PEH in these categories (48% and 68%). The general shift in body composition from underweight to overweight/obese matches previous and more recent studies of PEH that did not meet our eligibility criteria.<sup>7,31,32</sup> However, the Glasgow-based study also reported a high proportion of individuals with an underweight BMI (17%), which could be related to high local rates of drug and alcohol misuse.<sup>33,34</sup>

Data on serum micronutrient levels were highly heterogeneous across studies making comparison difficult. Local reference ranges were not available for one study based in Seoul,<sup>25</sup> whereas another study, based in the same city, had reference ranges for only some micronutrients and identified deficiencies in vitamin C.<sup>24</sup> The third study with serum micronutrient data only reported proportions of participants with deficiencies in certain micronutrients such as iron, folate, and vitamin B12 rather than the micronutrient levels themselves and thus were not directly comparable.<sup>23</sup>

### Comparison with previous reviews

Our findings suggest that unhealthy BMI (both overweight/obesity and underweight) could be more prevalent in PEH than previously thought.<sup>16</sup> A rise in overweight/obesity prevalence in PEH may be expected as part of the societal level obesity pandemic.<sup>16</sup> However, the suggestion of a concomitant rise in the prevalence of underweight is concerning and requires further investigation. Our finding of low vitamin C levels consolidates findings from previous reviews.<sup>13,15,16</sup> By way of possible explanation, previous literature described PEH's diets being high in dietary fats and alcohol, and low in fruit and vegetables.<sup>13,16</sup>

### Implications of research in the wider context

The high rates of unhealthy BMI and vitamin C deficiency among PEH demonstrate the need for detailed nutritional assessments of this population involving multiple measures of nutrition rather than relying on single measures. For example, many PEH may have a BMI within the healthy or overweight/obese ranges yet have vitamin or nutrition deficiencies. Validated tools like the Malnutrition Universal Screening tool, which primarily uses anthropometry, could be used in conjunction with serum biomarker and vitamin levels for routine assessment of the nutritional status of PEH.<sup>35</sup> Furthermore, handgrip strength, a cheap and quick measure of malnutrition and physical function, could provide useful information if integrated into routine clinical services for PEH.<sup>29</sup> Interventions shown to be effective in increasing consumption of fruits and vegetables in PEH with problem alcohol use could be translated into practice to improve the nutritional status of PEH<sup>12</sup> alongside improved support for lifestyle changes including smoking cessation (cigarette smoking depletes vitamin C levels) and management of problem alcohol use.<sup>36,37</sup>

Evidence for the need to address malnutrition in the general population is strong. Meta-analyses show that early identification and management using oral nutritional supplements can reduce the risk of clinical complications of malnutrition by 70% and mortality by 40%.<sup>38,39</sup> Therefore, among PEH, where malnutrition rates are higher and more severe, identifying and addressing malnutrition could be expected to generate even greater benefits.

### Strengths

To the best of our knowledge, there is no previous review of literature concerning the nutritional status of PEH with robust methodology involving a prespecified protocol, a comprehensive and systematic search strategy, transparent data synthesis, and quality appraisal. Therefore, this systematic review and its narrative synthesis provide a strong foundation for further research. The nutritional deficiencies observed in the included studies emphasise the need for the development of interventions to identify and treat nutritional deficiencies in PEH. This review identifies potential nutritional markers in PEH which could be targeted such as micronutrient supplementation and reduction of dietary fats and alcohol intake. Our review also highlights the dearth of literature that focusses on the nutrition of this vulnerable population. With only six studies included and with all studies being from high-income countries, more studies are required to understand the nutritional status of PEH from a wider range of settings and cultures.

### Limitations

Our review focussed on the general adult homeless population to inform services and research into PEH more generally. Therefore, our exclusion criteria may have led to the omission of some relevant data (Excluded studies, [Supplementary Material](#)). For example, excluded studies of families or mother-child duos experiencing homelessness may contain relevant nutritional data. However, such studies do not always report adult and child data separately and, typically, specialist homelessness services exist to address the needs of these populations, including their nutritional needs (e.g., iron deficiency anaemia in women of childbearing age). Studies reporting the nutritional content of meals provided by shelters and NGOs may provide reasonable indications of nutrition intake in the absence of more direct measures of diet. However, these data were



excluded as they are insufficient to describe the nutritional status of PEH without additional associated nutritional data, e.g., the extent to which shelter meals contribute to overall dietary intake.

As with most research concerning PEH, included studies are limited by small sample sizes due to difficulties in recruitment of this transient and hard-to-reach population. Participants of studies in this review were recruited from settings such as shelters, drop-in centres, and hospitals. However, there are likely to be ‘hidden’ PEH who do not present at these settings for meals and have more extreme levels of malnutrition. The data reported in included studies were highly heterogeneous with BMI being the only standardised measure reported by some studies. Biochemical data alone is of limited value in the assessment of nutritional status and can change on a daily basis.<sup>40</sup> Two included studies, despite their focus on nutrition, only reported biochemical data, making their contribution to describing the nutritional characteristics of PEH more limited.<sup>24,25</sup> Finally, recruitment in these two studies was based on attendance at emergency departments and because acutely unwell patients are more likely have deranged micronutrient levels, data from these studies may not be representative of PEH more generally.

## Conclusions

Unhealthy BMI (both underweight and overweight/obese) are more prevalent in PEH than in housed populations, as are high levels of vitamin C deficiency. Low levels of fruit and vegetable consumption are likely contributors to micronutrient deficiencies in PEH, alongside high levels of smoking and problem alcohol use. To the best of our knowledge, this is the first systematic review of the nutritional characteristics of adult PEH. However, extant studies are limited and heterogeneous, highlighting an evidence gap and the need for further research.

## Author statements

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## Ethical approval

This is a systematic review of literature and ethical approval is not required.

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## Competing interests

All authors declare no competing interests.

## Authors' contributions

RL conceived the idea for the project. CH, HF, and RL refined the research question and developed the study protocol. CH performed the database searches with supervision from HF, MW, and RL. CH and HF performed the study screening. VP performed the grey literature searches and screening. CH wrote the initial draft and HF, VP, MW, and RL made significant contributions to subsequent drafts. RL is the study guarantor.

## Consent for publication

N/A

## Availability of data and material

All data available is presented in the main manuscript and supplementary material.

## Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.puhe.2022.04.013>.

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