

## Review Article

# Place and food insecurity: a critical review and synthesis of the literature

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### Abstract

**Objective:** In some high-income countries, a sizeable proportion of households are estimated to be food insecure. It is well known that food insecurity varies between countries and is strongly tied to household income level. The local environment may be another level of influence, which has been relatively understudied. The present review sought to synthesize and critically appraise the existing literature examining local environmental characteristics in relation to individual/household-level food insecurity in the general population.

**Design:** A systematic search strategy was used to search MEDLINE, MEDLINE In-process and Other Non-indexed, EMBASE, PsychINFO, Social Services Abstracts and Sociological Abstracts databases for studies examining local place characteristic(s) in relation to self-reported food insecurity.

**Setting:** Studies could be experimental or observational, but had to be published in a peer-reviewed journal in French or English, and involve individuals from developed countries. 'Place' was defined locally, as ranging from the street to the county level.

**Subjects:** The target population for the review included non-institutionalized individuals in the general population.

**Results:** After obtaining full-text articles, eighteen primary studies met the eligibility criteria. Most studies were conducted in the USA and all but one was cross-sectional. Seven of the eleven studies that examined location of residence found that rural living was inversely associated with food insecurity. Mixed results were seen for other place measures such as social capital and distance to food stores.

**Conclusions:** Studies were heterogeneous and had various limitations that preclude definitive conclusions from being drawn. Recommendations for future research are provided.

**Keywords**  
Food insecurity  
Review  
Environment  
Local area  
Place

The Canadian government prioritized the right to food in 1998 in response to the 1996 World Food Summit<sup>(1)</sup> and since 1948 has signed many agreements emphasizing food as a human right<sup>(2)</sup>. Yet in 2007–2008, 7·7% of Canadian households (almost one million) were food insecure<sup>(3)</sup>; a concerning public health problem that is echoed in other high-income countries such as the USA<sup>(4)</sup> and Australia<sup>(5)</sup>. In the USA, for instance, one of the richest countries in the world, 14·5% of American households (17·2 million) were food insecure at some point during 2010. On average, these households experienced food insecurity for seven out of the twelve months of the year<sup>(4)</sup>.

Food insecurity exists when there is limited or uncertain access to nutritionally adequate and safe foods or limited or uncertain ability to acquire acceptable foods in socially acceptable ways<sup>(6)</sup>. There are different stages of severity, starting with not being able to buy and eat what one would like due to income-related resource constraints<sup>(7)</sup>. This incorporates issues of food quality including variety, safety and nutrient content. The next stage involves a decrease in quantity and attempts to make food last until there is money to buy more. Decreases in food quantity may then lead to the physical sensation of hunger<sup>(7)</sup>. Finally, the most severe stage is the complete absence of food intake. In addition to

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quality and quantity elements, psychological distress (e.g. worry or concern about not having enough to eat) and social-familial perturbations (e.g. resorting to socially unacceptable ways of getting food) are also important dimensions of food insecurity<sup>(8–10)</sup>.

Studies, conducted for the most part in the USA, have uncovered health correlates of food insecurity that include increased depression<sup>(11)</sup> and nutritional inadequacies<sup>(12,13)</sup> among adults, and psychosocial<sup>(14,15)</sup> and physical<sup>(16,17)</sup> developmental problems among children. Food insecurity has been found to relate to overweight or obesity; however, results are more consistent among women than among men and children<sup>(18,19)</sup>. There is also some evidence that food insecurity is related to CVD risk factors<sup>(20,21)</sup>. And finally, those dealing with food insecurity may also be more likely to postpone needed medications and medical care, in order to make sure that basic needs are addressed first<sup>(22)</sup>. Since most of these studies are based on the US population, correlates may be different in different countries. This may be especially true for postponing needed medications and medical care, as health-care systems differ among high-income countries.

The major determinant of food insecurity is well understood to be a lack of financial resources<sup>(23)</sup>. Active public policies to decrease poverty and protect the vulnerable non-poor are major ways society can meet the needs of citizens<sup>(24)</sup>; yet, in countries such as Canada the social safety net is shrinking<sup>(2)</sup> and more and more Canadians are relying on food banks. In 2010, food bank use across Canada was the highest on record, and did not decrease in 2011<sup>(25)</sup>. This is concerning for Canadians, especially when taking into consideration the current world economic outlook, high food prices and high food price volatility<sup>(26)</sup>.

Considering multiple levels of potential societal influence is consistent with a social-ecological approach to understanding public health problems. The link between macro socio-political and individual-level economic factors and food insecurity is relatively well established. What is less well known is how attributes of the local environment may be implicated. A focus on developing an understanding of the local environment in relation to food insecurity therefore deepens our overall understanding of this complex public health problem.

Recent research attempting to elucidate the effects of local social and physical characteristics of place on physical activity, diet and weight status of community residents may be relevant for identifying factors that can promote or prevent food insecurity (see Leal and Chaix<sup>(27)</sup> for an example). In the USA, there is convincing evidence of the existence of food deserts: area-level disparities in affordable, healthy food access by income and race<sup>(28)</sup>, which could translate into increased food insecurity for area residents. Availability of supermarkets has been linked to healthier eating<sup>(29)</sup> and supermarkets have also been shown to have lower food prices

compared with smaller stores<sup>(30)</sup>. Food quality may also vary depending on affluence of the area and living location<sup>(31)</sup>. Areas with high social capital – in particular, trust, reciprocity, shared norms and the willingness to enforce these norms – may allow residents to obtain food from neighbours or other institutions more easily in times of need and to act collectively to address food insecurity issues<sup>(32)</sup>. Disintegrating aesthetics of an area due to anti-social activity may act to dissuade food service establishments and other institutional supports from locating in particular areas, and perceived danger may prevent residents from accessing nearby food resources<sup>(33)</sup>.

Finally, there is some evidence from the USA to show that community-based initiatives such as community gardens<sup>(34)</sup> may increase the consumption of fruits and vegetables among disadvantaged participants. Thus, interventions or programmes that are place-based may increase the availability, accessibility and utilization of food to local residents and therefore work to decrease individual/household food insecurity.

The purpose of the present paper, therefore, was to conduct a comprehensive and critical review of the published literature in order to shore up the knowledge base on place and food insecurity. The intent was not to conduct a systematic review, rather to undertake a review which may serve to inform future reviews and identify research gaps for further study. The specific research review question was: among experimental and observational studies, have local physical and social environmental factors been found to significantly relate to individual/household-level food insecurity in the general population?

## Methods

### *Eligibility criteria*

Research studies were considered for inclusion if they examined the relationship between features of place and self-reported food insecurity (either at the household/family or individual level). The target population for the review included non-institutionalized individuals in the general population, but did not exclude studies that focused specifically on demographic subgroups. Only those studies that examined populations living in countries: (i) with a democratic political system and (ii) defined as 'very high human development' by the UN<sup>(35)</sup> were included.

'Place' was broadly defined as having a spatial or area component beyond an individual's residence; although the scale of place considered in the review ranged from the street to the county level. Studies examining larger areas were excluded. Place predictors could be perceived by individuals or objectively measured. Specific measures of interest included social capital (various definitions), crime, safety, density/distance to food stores, quality and prices at these local food stores, population/residential density, socio-economic status (SES)/deprivation and

local infrastructure making access to food easier (e.g. availability of public transportation, well-maintained sidewalks, route connectivity and directness, traffic, etc.). The outcome, food insecurity, had to be self-reported by the participating individual, on behalf of him- or herself, or on behalf of the household, and measured by a survey/questionnaire touching on one or more dimensions of not getting enough to eat due to lack of financial resources (e.g. food quality and variety, food quantity, physical hunger, anxiety/psychological distress, social aspects affected such as stealing or not inviting people over for dinner). Studies that used proxy measures for food insecurity, such as food stamp use, poverty status, food bank or pantry use, were excluded. Those that assessed community food insecurity as the outcome were also excluded.

Individual sociodemographic/socio-economic characteristics may act as confounders in the place–food insecurity relationship; thus, studies that did not adjust for some measure of household or individual SES were excluded. Considering that studies had to conduct multivariate analysis, those that had small sample sizes ( $n < 100$ ) were excluded. Only primary studies and reviews that used systematic search methods were considered for inclusion.

Study designs could be observational, as long as there was a comparison group or groups that was either not exposed to the place predictor or had varying levels of exposure. Intervention studies of different programmes/initiatives were included if they were newly implemented or modified, local in scope and delivered on a community-wide scale, helped to increase food availability and accessibility, and used (at the very least) a before-and-after design. Qualitative studies were excluded. Finally, due to resource and time constraints articles that were not written in French or English, or not published in peer-reviewed scientific journals, were excluded.

### ***Search strategy and identification of studies***

Six electronic databases were searched in December 2011 using a systematic search strategy. MEDLINE In-process and Other Non-indexed Citations, MEDLINE, EMBASE and PsychINFO were searched using the OvidSP interface, while Social Services Abstracts and Sociological Abstracts were searched using the ProQuest interface. No restrictions on time period were imposed. The search strategy was developed first in OvidSP and then refined as appropriate in ProQuest to account for changes in indexing of subheadings. Both free-text terms and indexed subheadings were used. The full search strategy for MEDLINE is available in the Supplementary Materials.

In OvidSP, all four databases were searched simultaneously and duplicates removed. Citations were saved and imported directly into Reference Manager version 12. Given ProQuest's difficulty in downloading a large number of citations, the two social databases (Social Services Abstracts and Sociological Abstracts) were

searched separately; citations were handled in the same way as OvidSP. All studies downloaded into Reference Manager first underwent a duplicate search. The first screen involved examining the titles and abstracts to determine if studies met eligibility criteria. Full-text articles were then obtained for those studies that appeared to meet the eligibility criteria and for those where it was unclear. Eligibility was assessed again, based on information in the entire article. Hand-searching the reference lists of included studies was also undertaken in order to retrieve studies missed from the original search strategy. Reviews were included solely for this purpose, as data from the review itself were not collected.

### ***Data abstraction***

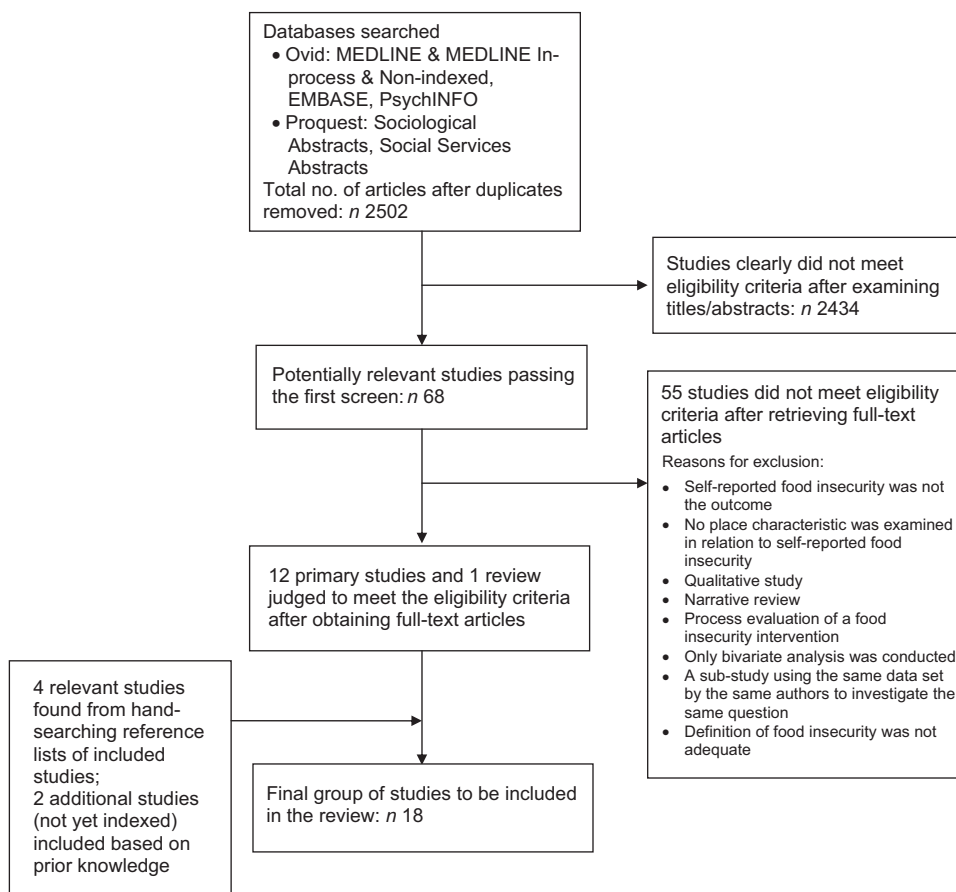
Details on the study characteristics were abstracted to provide a summary of implementation and results and a critical overview of study quality. Information abstracted included study design (e.g. cross-sectional, ecological, case-control, cohort, experimental/intervention), sampling strategy, survey/questionnaire administration mode (e.g. face-to-face interviews, telephone interviews, self-administered questionnaires), level of analysis (e.g. individual level or multilevel), sample characteristics (e.g. age, country, ethnicity, income level), total and effective/analytic sample sizes, cooperation and/or response rate(s), definition of the place characteristic as well as the area described by the characteristic, definition of food insecurity, statistical method used and the confounders included, results, and other unique aspects of the study that warranted special attention, specifically in regard to potential limitations.

## **Results**

### ***Literature search and general overview***

A total of 2502 potential articles were retrieved from the six databases. Of these, eighteen primary studies, and one review<sup>(36)</sup>, met the eligibility criteria (Fig. 1). Four of the included studies resulted from hand-searching the reference lists of other included studies<sup>(37–40)</sup>, while two studies were included based on prior knowledge using other search tools and journals (these had not yet been indexed in Ovid's MEDLINE, although they have been published subsequently)<sup>(41,42)</sup>.

Almost three-quarters (13/18) of the primary studies included were conducted in the USA, three were conducted in Australia, one in Canada and one in the UK (Table 1). All except one study were conducted in the year 2000 or later. The cross-sectional research design was almost exclusively used. Sample sizes across studies ranged from 330 to 70 942. Only four studies conducted multilevel analyses, while the rest conducted analyses at the individual level. For the most part, the areas defining the place characteristics were either based on administrative boundaries or perceived by the respondent.



**Fig. 1** Flow diagram of study selection

In terms of characteristics of the target populations studied, seven of the eighteen studies examined adults of varying ages<sup>(37–39,43–46)</sup>, seven explicitly examined families with children (sometimes with data collected using the child as the sampling unit)<sup>(40,42,47–51)</sup>, three focused on seniors<sup>(41,52,53)</sup>, and one sampled a range of ages (children and adults)<sup>(54)</sup>. Seven out of the eighteen studies (39%) focused exclusively on low-income or ethnic subgroups<sup>(39,44,46,48–51)</sup>.

Almost all included studies used either validated tools to measure food insecurity or individual questions from validated tools. Four studies used the US Department of Agriculture's (USDA) eighteen-item Food Security Scale<sup>(40,44,48,51)</sup>, although Kirkpatrick and Tarasuk (2010)<sup>(48)</sup> applied Health Canada's thresholds to define moderate and severe food insecurity. Five studies used the six-item short form of the USDA Food Security Scale<sup>(37–39,42,47)</sup>, three studies used items from the Community Childhood Hunger Identification Project in the National Health and Nutrition Examination (NHANES) III surveys<sup>(46,50,53)</sup>, and one study was based on items administered in the Behavioral Risk Factor Surveillance System<sup>(41)</sup>. The three Australian studies<sup>(45,52,54)</sup> and Dean and Sharkey (2011)<sup>(43)</sup> adapted and used items from the

Radimer/Cornell measure, while Sharkey *et al.* (2011) used an adapted version of the complete Radimer/Cornell measure<sup>(49)</sup>. Eight studies investigated different types or degrees of severity of food insecurity, by using either more than one questionnaire item or different thresholds for the USDA eighteen-item Food Security Scale or the Radimer/Cornell Scale<sup>(41,43–45,48–51)</sup>.

Four general types of place factors emerged from the synthesis. For brevity and integration of findings, results of included studies are discussed under the relevant subheadings below. Table 1 details the characteristics of each included study.

### **Living location**

The most common place characteristic examined was living location, as measured on the urban–rural continuum; eleven studies assessed the potential impact of this area-level exposure on food insecurity<sup>(37–40,43,45,47,50–53)</sup>. Most often, this place factor was simply defined as urban *v.* rural with no clear explanation of the administrative boundaries or criteria used.

Seven studies uncovered a potential protective effect of rural living on food insecurity. Garasky *et al.* (2006) compared two subject-perceived definitions of rural

**Table 1** Characteristics of studies included in the present review

Study	Design	Sample	Place factor(s)	Place boundary definition	Food insecurity	Statistical method; & adjustments	Results	Notes and potential limitations
Bartfeld and Ahn <sup>(51)</sup>	XS, I, NRS, TQ for parents	3rd graders in wave 5 (2002) of the Early Childhood Longitudinal Survey-Kindergarten cohort (USA); limited to low income (<185% of the poverty line); info from parent and school administrator surveys used; <i>n</i> 3010; total survey <i>N</i> not reported	(1) Median rent (\$US/month)  (2) Living location: - large city - mid-sized city - large suburban - small town - large town - mid-sized suburban - rural area in MSA - rural area outside MSA (Ref)	(1) Zip-code level  (2) Unclear	18-item USDA Food Security Scale:  - (A) food secure v. food insecure (replied affirmatively to at least 3/18 items)  - (B) fully food secure v. marginally food secure (replied affirmatively to any of the 18 items)	Probit regression;  & Survey weights, clustering of households within schools (robust SE), school breakfast availability; household income, education, family type/employment status and ownership status; parent's health status, # of children in household; race/ethnicity of child; school offers after-school child care, has a free/reduced price meal certification, or receives Title I funds (measures of school disadvantage); other place factor, region of residence	A  (1) + $\beta = 0.0005$ , SE = 0.0002, $P < 0.05$ ; (2) + small towns, $\beta = 0.415$ , SE = 0.126, $P < 0.01$ ; + mid-sized suburbs, $\beta = 0.383$ , SE = 0.138, $P < 0.01$ ; + mid-sized cities, $\beta = 0.224$ , SE = 0.113, $P < 0.05$ B Ø for (1) and (2) for all types v. Ref	Living location not the main objective; sex of parent respondent not controlled; large # of children ( <i>n</i> 3840) excluded because they were missing parent and/or administrator surveys; school disadvantage was controlled but area disadvantage may be a confounding factor
Bartfeld <i>et al.</i> <sup>(47)</sup>	XS, CS of schools, SAQ	Parents/guardians of elementary-school children attending 65 schools in 26 counties in Wisconsin (USA); recruitment lasted from 2003 to 2005; <i>n</i> 8396; mean RR across schools = 69% (range: 30–91%)	(1) Median monthly rent (increments of \$US 100) (2) Access to public transit (yes/no) (3) Distance to nearest supermarket or grocery store: - <2 miles - 2–<5 miles (Ref) - 5–<10 miles - 10–<15 miles - 15–22 miles (4) Proportion living in poverty (US 2000 Census data def) (5) Proportion living in an urban area (US 2000 Census data def)	(1, 4, 5) Zip code (2) Perceived (3) Straight line distance from geographic centre of zip code	USDA 6-item Food Security Scale short-form:  - food insecure (responded affirmatively to $\geq 2$ items)	Logistic regression; & Clustering of households within schools (robust SE), income, household structure, # of children, housing tenure, education, # of employed persons, ownership of a working vehicle, other place factors	(1) + OR = 1.21, $P < 0.01$ ; (2) – OR = 0.68, $P < 0.01$ ; (3) + for 15–22 miles, OR = 1.67, $P < 0.01$ ; (4) Ø OR = 1.98, $P > 0.05$ ; (5) + OR = 1.44, $P < 0.05$	NG and CS are potential limitations; could not adjust for race/ethnicity; did not control for sex of the respondent; distance to nearest supermarket/store was not based on respondents' residence (correlation was not strong with self-reported distance, $r = 0.27$ ); could year of interview or differences in RR across schools have influenced results?

Table 1 Continued

Study	Design	Sample	Place factor(s)	Place boundary definition	Food insecurity	Statistical method; & adjustments	Results	Notes and potential limitations
Bartfeld and Dunifon <sup>(40)</sup>	XS, ML, NRS	Households with children in the US Current Population Survey (Food Security Supplement) 1998–2001; <i>n</i> 70 942; supplemented with state-level data	Living location: - central city - other metropolitan area (Ref) - non-metropolitan area	Administrative boundaries (county)	18-item USDA Household Food Security Scale: - food secure v. - food insecure	ML logistic regression (state) controlling for year of survey; & Household: income, education, race/ethnicity, housing tenure, number of children, family type, characteristics of household members (e.g. disabled); State: federal food programmes, school breakfast and lunch programme participation, summer food service programme participation, summer school lunch programme participation, low income tax burden, overall tax burden, unemployment rate, poverty rate, % with a bachelor's degree, average wage, median rent, residential mobility	+ Central city OR = 1·06, SE = 0·03 – Non-metropolitan OR = 0·91, SE = 0·03	Sex of parent respondent not controlled; CR/RR across surveys not reported; small effect sizes; sensitivity analysis indicated different results for state-level variables among families without children; interview mode unclear
Bernell <i>et al.</i> <sup>(38)</sup>	XS, I, RS, TQ	Participants of the 2000 Oregon (USA) Population Survey; aged ≥18 years and head of the household; analytic <i>n</i> 4725; supplemented by census data and other government statistics at the county level	(1) % of county considered rural under the US Census Bureau def (2) County unemployment rate (%) (3) County average wage (\$US) (4) High county rent (county ranking in top quartile of state median rent distribution) (5) % of county population claiming a religious affiliation (6) % of county population that moved within the last 5 years	Administrative boundaries (county)	USDA 6-item Food Security Scale short-form: - food insecure (responded affirmatively to ≥2 items)	Logistic regression; & Income, family structure, race/ethnicity, education, age, disability status, employment status, volunteer in community, homeowner, proportion of county using food stamps, other place factors	(1) – $\beta = -0·023$ , $P < 0·01$ ; (2) $\emptyset$ $\beta = 0·060$ , $P > 0·1$ ; (3) $\emptyset$ $\beta = -0·029$ , $P > 0·1$ ; (4) + $\beta = 0·330$ , $P < 0·01$ ; (5) $\emptyset$ $\beta = 0·001$ , $P > 0·1$ ; (6) $\emptyset$ $\beta = -0·018$ , $P > 0·1$	Relied on RDD; did not control for sex of the respondent; CR/RR and total <i>N</i> not reported; tested for interaction between income and county rent in a second model – rent appeared to be important only for lowest income quartile

Table 1 Continued

Study	Design	Sample	Place factor(s)	Place boundary definition	Food insecurity	Statistical method; & adjustments	Results	Notes and potential limitations
Brisson and Altschul <sup>(46)</sup>	XS, ML, CS of nhoods within 10 US cities, then SRS of households	Low-income residents (median age 40 years) participating in the Making Connections Initiative 2002–2003; <i>n</i> 7496	Collective efficacy: two subscales developed by Sampson <i>et al.</i> (1997), 5 items per subscale measured on a 5-point Likert-type scale (1 = strongly disagree to 5 = strongly agree):  (1) Social cohesion–individual (2) Social cohesion aggregated by nhood (3) Informal social control–individual (4) Informal social control aggregated by nhood	Nhood boundaries that conformed to socially accepted norms (census blocks)	'In the last 12 months...was your family ever without enough money to buy food?' (yes/no)	ML structural equation modelling using probit regression (nhood); & Individual level: race, poverty, access to credit, savings, other place factors	(1) – $\beta = -0.176$ , SE = 0.037, $P < 0.001$ ; (2) – $\beta = -1.42$ , SE = 0.672, $P < 0.05$ ; (3) $\emptyset$ $\beta = 0.056$ , SE = 0.035; (4) $\emptyset$ $\beta = 1.13$ , SE = 0.651	NG and selection of nhoods are potential limitations; missing some potential confounders (e.g. sex of the respondent, household structure); interview mode unclear; no CR/RR given; nhood explanatory variables such as SES and homeownership were dropped because model fit decreased; food insecurity assessed with 1 question; clustering effect of city was not considered; could non-normality of subscales affect results?
Chung <i>et al.</i> <sup>(41)</sup>	XS, ML, CRS (with stratification), F2F	Older adults $\geq 60$ years attending senior's centres Apr–Nov 2008 (Health Indicators Project) in New York City; <i>n</i> 1870; <i>n</i> analytic sample 1650; RR = 76.7 %	(1) Nhood walkability scale – 8 items with binary responses summed to derive scale score (continuous paved sidewalks, curb cuts, crossable sections, lighting at night, benches on which to sit, cracks in sidewalks, uneven sidewalks, and excessive noise from traffic/car alarms/trains) (2) Nhood safety – 3 items measured on 4-point Likert scale (1 = very true to 4 = not at all true) summed to derive scale score (3) Nhood social cohesion – 5 items measured on a 4-point Likert scale (1 = very true to 4 = not at all true) summed to derive scale score	(1–3) Perceived	(A) 'In past 30 d, have you been concerned about having enough food to eat?' (yes/no) (B) 'In the last 12 months did you ever eat less than you felt you should because there wasn't enough money to buy food?' (yes/no) (C) 'In the past 12 months, were you hungry, but did not eat because you weren't able to get out to buy food?' (yes/no)	ML logistic regression (senior's centre); & Individual level: age, sex, married or partnered, race/ethnicity, education level, physical disability, mental health status, chronic condition status, social support, income level (income not included for model with B as outcome); other place factors	A (1) – OR = 0.83, 95 % CI 0.73, 0.95; (2) $\emptyset$ OR = 0.97, 95 % CI 0.91, 1.04; (3) $\emptyset$ OR = 1.0, 95 % CI 0.96, 1.04 B (1) marginally – OR = 0.87, 95 % CI 0.75, 1.00; (2) $\emptyset$ OR = 1.05, 95 % CI 0.98, 1.13; (3) $\emptyset$ OR = 0.97, 95 % CI 0.92, 1.01 C (1) – OR = 0.84, 95 % CI 0.70, 0.99; (2) $\emptyset$ OR = 1.07, 95 % CI 0.96, 1.20; (3) $\emptyset$ OR = 0.96, 95 % CI 0.90, 1.03	Low internal consistency of walkability scale; unclear if the distribution of the scales was highly skewed, especially for safety and cohesion; used multiple imputation for the three nhood factors; questions ask about nhood but clustering accounts for senior's centre; no nhood-level variables in the model, although stratification in sampling accounts for size of senior's centre

Table 1 Continued

Study	Design	Sample	Place factor(s)	Place boundary definition	Food insecurity	Statistical method; & adjustments	Results	Notes and potential limitations
Dean and Sharkey <sup>(43)</sup>	XS, I, RS, SAQ	Adults living in Texas (USA), participating as part of the 2006 Brazos Valley Health Assessment; RR = 73·8 % (2584/3501); <i>n</i> analytic sample 1803 (slightly more women)	(1) Community social capital index of Burdine <i>et al.</i> (1999) – 6-items measured on a 5-point scale (1 = strongly agree to 5 = strongly disagree); quartiles from standardized score calculated and used to form 3 categories: - low social capital (highest quartile) - medium social capital (middle two quartiles) - (Ref) high social capital (lowest quartile) (2) Rural v. urban (Ref)	(1) Perceived (2) Unclear	Food depletion item from the Radimer/Cornell hunger and food insecurity – 'Within the last month..the food that we bought didn't last and we didn't have enough money to buy more' with 3 response categories: - (A) 'often true' - (B) 'sometimes true' - (Ref) 'never true'	Multinomial logistic regression – modelled all variables, then stratified by rural/urban (results did not differ so not presented here); & Education, age, gender, ethnicity, income level, perceived personal disparity, other place factors	A (1) Ø Medium OR = 0·73, 95 % CI, 0·41, 1·20; + Low OR = 1·87, 95 % CI 1·51, 4·63; (2) + OR = 1·83, 95 % CI 1·10, 3·06 B (1)+Medium OR = 1·73, 95 % CI 1·17, 2·57; + Low OR = 2·90, 95 % CI 1·91, 4·41; (2) Ø OR = 1·10, 95 % CI 0·81, 1·50	Possible over/under-sampling of certain areas; food insecurity assessed by only 1 question; sampling based on RDD (although authors indicate coverage was over 95 %, based on 2000 census); no control for area-level SES
Foley <i>et al.</i> <sup>(54)</sup>	XS, I, RS, TQ	Respondents from the South Australia Monitoring and Surveillance System (all ages) July 2002–Dec 2007; CR = 70 % for main survey ( <i>n</i> 37 976); analytic <i>n</i> 19 037	(1) Neighbours trust each other (yes/no) (2) Live in a safe nhood (yes/no) (3) Socioeconomic Index for Areas (categorized based on quintiles)	(1,2) Perceived (3) Postcode	'In the last twelve months, were there any times that the food you have bought just didn't last, and you didn't have enough money to get more?' (yes/no)	Logistic regression; & Survey weights, sex, age group, education, work status, household income, capacity to save, housing tenure, # of children in household, other place factors	Ø for (1), (2) and (3) and were excluded during multivariable analysis, results not given	Used phone # lists to select sample; no adjustment for survey year/ cycle; only half of the main survey sample had data on food insecurity (19 037/37 976); excluded place factors during multivariable analysis; 1 question used to assess food insecurity



Table 1 Continued

Study	Design	Sample	Place factor(s)	Place boundary definition	Food insecurity	Statistical method; & adjustments	Results	Notes and potential limitations
Garasky <i>et al.</i> <sup>(37)</sup>	XS, I, SRS, SAQ	Individuals living in two rural Iowa (USA) counties in 2004; mean age of 54 years; <i>n</i> 793; RR = 62%; <i>n</i> analytic sample 562 (71% of responding sample had complete data)	(1) High prices in food stores where respondent lives (2) There are not enough food stores where the respondent lives (3) Living location: - on farm outside city limits - not on farm, outside city limits - within city limits (Ref)	Perceived	USDA 6-item Food Security Scale short-form: - food insecure (responded affirmatively to $\geq 2$ items)	Probit regression; & Age, education, household income, # of people in household, county, other place factors, shop outside county, difficult to get to store, transportation problems, can get help with transportation, food assistance programme participation index, informal social support index, gave food to family/friends/ neighbours index, received food from family/friends/neighbours index	(1) $\emptyset$ $\beta = 0.466$ , SE = 0.262, $P < 0.10$ ; (2) $\emptyset$ $\beta = 0.453$ , SE = 0.260, $P < 0.10$ ; (3) - on farm, outside city $\beta = -0.923$ , SE = 0.428, $P < 0.05$ ; $\emptyset$ not on farm, outside city $\beta = -0.478$ , SE = 0.294, $P < 0.10$	NG (e.g. high poverty, rural counties); source of sampling frame unclear (address lists were from governmental sources?); did not control for sex of the respondent; indices included had low internal reliabilities
Kirkpatrick and Tarasuk <sup>(48)</sup>	XS, ML, CRS with stratification; F2F	Low-income families with children living in rental units in high-poverty nhoods (Toronto, Canada); recruited Nov 2005–Jan 2007 and respondent had to have primary responsibility for food purchasing and management; <i>n</i> families 484; RR = 62%	Do not live within 2 km of a: (1a) discount supermarket (1b) food bank (1c) community kitchen (1d) community garden (2) Adequacy of food retail in nhood (3) Nhoo social capital – 7-item, 4-point Likert-type scale (based on work of Sampson <i>et al.</i> , 1997) – measures social cohesion and trust in nhoo at the household level; dichotomized based on a score of 3: - low v. - medium/high (Ref)	(1a–d) Within 2 km of residence; continuous distances, and within 1 km also considered (2,3) Perceived nhoo	18-item USDA Household Food Security Scale, categorized based on Health Canada thresholds: - food secure - food insecure Also examined severely food insecure v. not (results were similar so are not presented here)	ML logistic regression (nhoo); & Income, # of adults and children in household, main source of income, family structure, education, immigrant status, housing type (market rental or subsidized), # of years in current dwelling (social capital only); (1a–d) and (2) included in first model with adjustment, and (3) was analysed in separate model with adjustment	(1a) $\emptyset$ OR = 0.73, 95% CI 0.43, 1.26; (1b) $\emptyset$ OR = 0.82, 95% CI 0.55, 1.22; (1c) $\emptyset$ OR = 0.78, 95% CI 0.52, 1.17; (1d) $\emptyset$ OR = 1.09, 95% CI 0.72, 1.65 Continuous distances and not living within 1 km were also $\emptyset$ for (1a–d) (2) $\emptyset$ OR = 0.87, 95% CI 0.53, 1.41; (3) $\emptyset$ OR = 1.33, 95% CI 0.88, 2.00	NG and sample very homogeneous; no adjustment for sex, although respondent was person responsible for food management; measured type and cost of transportation, as well as whether respondents shopped in their local area, but unclear when these were included in adjustment; could year of interview have influenced results?

Table 1 Continued

Study	Design	Sample	Place factor(s)	Place boundary definition	Food insecurity	Statistical method; & adjustments	Results	Notes and potential limitations
Lee and Frongillo <sup>(53)</sup>	XS, I, NRS + a state-level survey (sampling is unclear); F2F for NHANES III; survey mode unclear for the state-level survey	Elderly persons aged 60–90 years in NHANES III ( <i>n</i> 6596; <i>n</i> analytic sample 6558), plus elderly persons aged 60–96 years in the 1994 Nutrition Survey of the Elderly New York State ( <i>n</i> 553; <i>n</i> analytic sample 406)	(1) Living in metro area v. non-metro (Ref) in NHANES III (2) Living in New York City v. outside New York City (Ref)	Unclear	NHANES III: 'Do you have enough food to eat, sometimes not enough to eat, or often not enough to eat?' - food insecure = sometimes or often  1994 NY Survey: $\geq 1$ affirmative response to 3 questions assessing: - enough money to buy food - skipping meals because not enough food - choosing between buying food or paying bills/essential items	Separate logistic regression models by survey; & Survey weights and design, age, poverty status, race/ethnicity, education, health status, social isolation, living arrangement, physical functioning, food assistance	(1) $\emptyset$ OR = 0.75, 95 % CI 0.50, 1.11; (2) $\emptyset$ OR = 0.62, 95 % CI 0.30, 1.03	Possible under-reporting of food insecurity; food insecurity based on few questions; sex was assessed in exploratory analysis but unclear if included in the multivariate model
Martin <i>et al.</i> <sup>(44)</sup>	XS, I, RS, F2F	Low-income families in City of Hartford (USA); unclear who was targeted as the respondent; <i>n</i> 330; CR = 55 %; RR = 34 %	(1) Nhood social capital – 7-item, 4-point Likert-type scale (based on work of Sampson <i>et al.</i> , 1997) – measures social cohesion and trust in nhood at the household level, dichotomized based on median (score of 3): - low (Ref) v. - high (2) Nood social capital from individuals, aggregated up to the nhood level (mean of each nhood). Unclear if dichotomized based on a score of 3	(1) Perceived (2) 14 residential nhoods with geographic boundaries defined by the City Council in 1970	18-item USDA Household Food Security Scale – 4 categories (defined by Bickel <i>et al.</i> , 2000): a - food secure b - food insecure with risk of hunger c - food insecure with moderate hunger (at least one adult) d - food insecure with severe hunger (at least one child); dichotomized into hunger (c, d) v. no hunger (a, b)	Logistic regression; & Member of an organization, length of time in apartment, child under age 18 years, elderly member, single mother, race/ethnicity, income, education, employment status	(1) – OR = 0.87, 95 % CI 0.76, 0.99, $P < 0.05$ ; (2) – OR = 0.47, 95 % CI 0.28, 0.81, $P < 0.05$	NG; no adjustment for clustering within nhood; low CR; small <i>n</i> ; did not control for sex of the respondent; used hunger v. no hunger as outcome after finding null results for the less severe outcome food insecure v. food secure; measured car ownership but did not seem to control for it

Table 1 Continued

Study	Design	Sample	Place factor(s)	Place boundary definition	Food insecurity	Statistical method; & adjustments	Results	Notes and potential limitations
Mazur <i>et al.</i> <sup>(50)</sup>	XS, I, NRS, F2F	4–16-year-old Hispanic children participating in NHANES III; <i>n</i> 2985	Residential area: - metropolitan (Ref) (a central county of a metropolitan area with a population $\geq 1$ million) v. - non-metropolitan area	Administrative boundaries (counties)	(A) 'Do you have enough food to eat, sometimes not enough to eat, or often not enough to eat?' enough v. sometimes/often not enough (B) Meal sizes had to be cut for an adult because of lack of money for food (C) Meal sizes had to be cut for a child because of lack of money for food	Logistic regression; & Survey weights and cluster design, sex, age, Spanish used at home, low income, interaction between Spanish used at home and low income, household head's education & occupation, female-headed household, family receives food stamps, child uses vitamin or mineral supplements, parents living $\leq 10$ years in present house	A $\emptyset$ OR = 1.1, 95% CI 0.7, 1.8; B – OR = 0.5, 95% CI 0.3, 0.9, $P < 0.01$ ; C – OR = 0.5, 95% CI 0.2, 0.9, $P < 0.01$	Questions 2 and 3 not asked in the first phase and their effective <i>n</i> were 1120 and 1123 respectively (compared with <i>n</i> 2345 for question 1); few questions to assess food insecurity; proxies responded for children aged 4–11 years while children aged $> 11$ years responded themselves
Morton <i>et al.</i> <sup>(39)</sup>	XS, I, SRS, SAQ	Residents (mean 56 years) of 2 high-poverty, rural counties in Iowa (USA) with $\leq 4$ grocery stores (defined as a 'food desert') in 2003; <i>n</i> 720; RR = 49%, CR = 60%; analytic <i>n</i> 656	(1) Civic structure index – 7 items with a 1–4 response scale (low to high) summed and /7 (measures extent to which respondents perceive that local institutions and leaders are working to solve food access problems in the community) (2) Place of residence: - live in town v. - in countryside (Ref)	(1) Perceived community (2) Perceived spatial location relative to closest town	USDA 6-item Food Security Scale short-form: - food insecure (responded affirmatively to $\geq 2$ items)	Logistic regression; & Age, income, education, give food to family or friends, acquire meals from a senior meal site, acquire food from family or friends, other place factors	(1) – OR = 0.20, $P = 0.021$ ; (2) $\emptyset$ OR = 1.26, $P = 0.762$	NG (e.g. rural, only two counties, older population); did not adjust for county or sex of respondent; low RR; unclear if the distribution of the civic index was skewed

Table 1 Continued

Study	Design	Sample	Place factor(s)	Place boundary definition	Food insecurity	Statistical method; & adjustments	Results	Notes and potential limitations
Pilgrim <i>et al.</i> <sup>(42)</sup>	PC, I, F2F	Women aged 20–34 years registered with general practitioners in Southampton (UK), 1998–2002; RR = 75 %; follow-up for those eligible (had singleton births) was 83 %; <i>n</i> 1640; analytic sample <i>n</i> 1618 when child was 3 years of age	Index of Multiple Deprivation Score - analysed as continuous and as categorical variable: - less deprived (Ref) - more deprived - most deprived	Post codes	Adapted version of the USDA 6-item Food Security Scale short-form: - women scoring $\geq 2$ categorized as food insecure	Logistic regression; & Maternal age, benefit receipt, social class, smoking status, educational attainment, cohabitation status	Continuous (trend) + <i>P</i> for linear trend = 0.033 Categorical - more deprived $\emptyset$ OR = 1.39, 95 % CI 0.63, 3.04; - most deprived $\emptyset$ OR = 1.95, 95 % CI 0.91, 4.19	Vague description of place factor; NG (clinic-based sample of women); socio-economic/demographic and place variables measured before pregnancy but did not adjust for moving; also do not know if mother was already food insecure at baseline
Quine and Morrell <sup>(52)</sup>	XS, I, SRS, TQ	Non-institutionalized older adults $\geq 65$ years of age living in New South Wales, Australia from late 1999 to early 2000 (Older Person's Health Survey); <i>n</i> 8881; CR/RR = 70.7 %	Type of living location: - urban - large, urbanized rural centre - small rural centre - other	Unclear	'In the last 12 months, were there any times that you ran out of food and couldn't afford to buy more?' (yes/no)	Logistic regression; & Survey weights/design, sex, age, housing tenure, living arrangement, private health insurance, perceived financial situation, need household or personal help, self-rated healthy lifestyle	$\emptyset$ , statistics not reported	Low prevalence of food insecurity (due to possible under-reporting in this group, TQ method of data collection, and/or use of only 1 question to assess food insecurity)
Radimer <i>et al.</i> <sup>(45)</sup>	XS, I, SRS, TQ	Individuals aged $\geq 18$ years residing in 13 health regions in Queensland, Australia, March–Oct 1993; <i>n</i> 10 451; RR/CR = 75–80 % across strata (health regions); analytic sample was reduced to 70 % of <i>N</i> due to missing data	Living location: - urban v. rural (Ref)	Administrative boundaries (Australian Department of Health, Housing and Community Services Rural and Remote Classification)	(A) Household: 'In the last 12 months were there times that your household ran out of food and there wasn't money to buy any more food?' (yes/no) (B) Individual: 'In the last 12 months has anyone in your household eaten less than they should because you couldn't afford enough food?' (yes/no)	Logistic regression; & Survey weights, aged $\leq 50$ years, low income, sex employment status, single parent household, single, separated (including divorced or widowed), shared housing	A + OR = 1.3, 95 % CI 1.1, 1.6 B + OR = 1.3, 95 % CI 1.0, 1.6	<i>P</i> values not given for OR (outcome B may only be marginally significant); relied on RDD in 5 regions where % of unlisted #s was high (8–14 %) and on phone lists in remaining regions; food insecurity based on only 2 questions that were validated in the same study; 30 % not included in multivariate models – unclear if these participants differed

Table 1 Continued

Study	Design	Sample	Place factor(s)	Place boundary definition	Food insecurity	Statistical method; & adjustments	Results	Notes and potential limitations
Sharkey <i>et al.</i> <sup>(49)</sup>	XS, I, CRS with stratification, F2F	Adult Spanish-speaking women responsible for food prep living in one of 44 high-poverty colonias in S. Texas (Colonia Household and Community Food Resource Assessment, Sept–Oct 2009); <i>n</i> 610; RR = 97.3–99.4% based on stratification by two towns (La Feria and Progreso)	(1) Distance to main store for purchasing groceries (2) Quality of food environment on 4-point Likert scale (1 = strongly agree to 4 = strongly disagree): (a) little variety in types of foods that can be purchased (b) few grocery stores or supermarkets (c) food prices are high	(1) Absolute distance (2) Perceived	Eleven items from the 12-item Radimer/Cornell measure 4 mutually exclusive categories (respondents allocated based on pattern of responses to 11 items): - household food insecure - adult food insecure - child food insecure - food secure (Ref)	Multinomial regression; & Other place factors, Mexican-born, household composition, income, employment status of spouse or partner, participation in food assistance programmes, eating behaviours, alternative food sources	(1) + for adult OR = 1.19, $P \leq 0.01$ ; Ø for household (OR = 1.08) and for child (OR = 1.09) (2a) + for child OR = 3.32, $P \leq 0.01$ ; Ø for household (OR = 2.59) and for adult (OR = 1.98); (2b) and (2c) Ø for all forms of food insecurity relative to food secure, results not reported	NG; definition and enumeration of colonias using a 'windshield survey' by interviewers (issues of standardization); did not appear to consider potential clustering effect, at least by town; may be NG to rest of colonias in S. Texas as only small area sampled; transportation was considered but taken out of the final model due to non-significance; unclear how scales were dichotomized

XS, cross-sectional design; I, individual level; TQ, questionnaire/survey administered over telephone; CS, convenience sample; SAQ, self-administered paper questionnaire; ML, multilevel; RS, simple random sample; nhood, neighbourhood; SRS, stratified random sample; CRS, cluster random sample; F2F, face-to-face interviews; NHANES III, Third US National Health and Nutrition Examination Survey (1998–1994); PC, prospective cohort; *n*, number of participants; *N*, total number of sample; RR, response rate (# responding/# eligible); CR, cooperation rate (# responding/# eligible and able to contact); MSA, Metropolitan Statistical Area; Ref, reference category; def, definition; USDA, US Department of Agriculture; #, number; +, a significant positive/proportionate association; Ø, a null association; –, a significant negative/inverse association; NG, not generalizable; RDD, random-digit dialling; SES, socio-economic status.

living to urban living. They found that living outside the city on a farm was related to decreased food insecurity compared with living within the city limits, but there was no difference between living outside the city (not on a farm) and living within the city limits<sup>(37)</sup>. In a study of Oregon adults, the percentage of the county considered rural was inversely related to food insecurity<sup>(38)</sup>. Similarly, the percentage of people living in urban areas as defined by zip code was positively related to food insecurity in a study of Wisconsin families<sup>(47)</sup>. When examining two types of food insecurity (household and individual) based on two questions, Radimer *et al.* (1997) found that urban living in Australia was associated with increased odds for both types of food insecurity, *v.* rural living<sup>(45)</sup>. Among a Hispanic population, living in a non-metropolitan area relative to a metropolitan area was inversely related to food insecurity, as defined by cutting of children's or adult's meals, but not by an individual child feeling like he/she does not have enough to eat<sup>(50)</sup>. In a study of low-income families, Bartfeld and Ahn (2011) compared various types of towns/cities with respect to population size, defined by zip code<sup>(51)</sup>. Compared with rural areas outside MSA (Metropolitan Statistical Areas), low-income families living in small towns, mid-sized suburbs or mid-sized cities were more likely to be food insecure. Those living in large cities, large suburbs, large towns or rural areas within an MSA were no different from those living in rural areas outside an MSA. Finally, in a large, nationally representative sample of US families, living in a central city *v.* an 'other' metropolitan area was associated with increased odds of food insecurity, while living in a rural area was associated with decreased odds<sup>(40)</sup>.

Three of the eleven studies reported null results, whereas one reported a positive association between rural living and food insecurity. Two of the three null studies were conducted on older adults<sup>(52,53)</sup>. One of these used dichotomous indicators of living location (metropolitan *v.* non metropolitan living)<sup>(53)</sup>, while the other examined four different types of areas<sup>(52)</sup>. The third null study did not find that living in town differed from living in the countryside in two high-poverty Iowa counties with sample mean age of 56 years<sup>(39)</sup>. In contrast to the seven studies described above, Dean and Sharkey (2011) uncovered a positive association between rural living and food insecurity<sup>(43)</sup>. They conducted multinomial analysis with the response categories serving as an indication of the severity of food insecurity. A significant association was seen only for those in the most severe response category.

### **Social environment**

The nature of social interactions within residential areas was the second most studied place factor in the current review (eight out of eighteen studies), and included various measures of social capital, such as social cohesion, informal social control, collective efficacy, civic

structure, and related measures such as religious affiliation, residential mobility and neighbourhood safety<sup>(38,39,41,43,44,46,48,54)</sup>. Two studies examined characteristics of the social environment at both the individual and neighbourhood levels<sup>(44,46)</sup>, while the remainder focused solely on the individual level. Both of the former studies aggregated individual measures up to the neighbourhood level based on specified boundaries and focused on low-income populations. Brisson and Altschul (2011) examined collective efficacy as measured by indices for social cohesion and informal social control. Social cohesion, but not informal social control, was inversely related to food insecurity at the neighbourhood level<sup>(46)</sup>. In the second study, scoring high on a social capital index was found to inversely relate to severe food insecurity (hunger present) but not food insecurity without hunger (of which the authors did not report the results)<sup>(44)</sup>.

At the individual level, four out of the eight studies estimated a potential protective effect of high social capital<sup>(39,43,44,46)</sup>. Increasing score on a civic structure index was related to decreased odds for food insecurity in a study of two rural, high-poverty counties<sup>(39)</sup>. And in another study, scoring low or medium on a social capital index was related to increased odds for 'sometimes' being food insecure *v.* food secure, as compared with high social capital, in a mostly rural population of adults<sup>(43)</sup>. Interestingly, low social capital, but not medium, was related to being 'often' food insecure<sup>(43)</sup>. Martin *et al.* (2004) and Brisson and Altschul (2011) estimated similar associations at the individual level as at the neighbourhood level<sup>(44,46)</sup>.

The four null studies contained a variety of measures. For example, Foley *et al.* (2010) examined single items measuring trust in neighbours and safety of the neighbourhood<sup>(54)</sup>; Bernell *et al.* (2006) examined the proportion of the county having a religious affiliation, as well as the proportion that moved within the last five years<sup>(38)</sup>; Chung *et al.* (2011) included indices of neighbourhood safety and cohesion for three different food insecurity definitions<sup>(41)</sup>; and finally, Kirkpatrick and Tarasuk (2010) did not find an association between a social capital index and two types of food insecurity severity<sup>(48)</sup>. Population characteristics of these studies were similarly mixed.

### **Food environment**

Five studies investigated the potential influence of characteristics in the local food environment that could impact on food insecurity<sup>(37,41,47-49)</sup>; although only three uncovered significant associations. In their study of Wisconsin families with children, Bartfeld *et al.* (2010) estimated a positive association between living 15–22 miles from the nearest supermarket or grocery store *v.* less than 2 miles<sup>(47)</sup>. However, distances longer than 2 miles, but shorter than 15 miles, were not related to being food insecure. Similarly, distance to the main store

for purchasing groceries increased the odds for adult food insecurity, but not household or child food insecurity, in a study of Spanish-speaking women of Mexican origin living in a poor area of Texas<sup>(49)</sup>. This same study also found that those who perceived little variety in the types of foods that could be purchased in local stores were more likely to report child food insecurity, but not adult or household food insecurity (although the odds ratios were high and in the same direction for both types). In terms of features of the built environment that could improve access to food, Chung *et al.* (2011) estimated an inverse association between 'walkability' of older adults' neighbourhoods and two measures of food insecurity (concern about not having enough to eat; hungry because could not get out to buy food) and marginally with a third (eating less because of lack of money,  $P=0.056$ )<sup>(41)</sup>. In a similar vein, Bartfeld *et al.* (2010) found that household-perceived access to public transit decreased the odds for food insecurity<sup>(47)</sup>.

Two of the five studies were unable to detect any significant effects of the food environment<sup>(37,48)</sup>. In a low-income population, Kirkpatrick and Tarasuk (2010) investigated the association between food insecurity and living within 2 km of a number of food resources, including discount supermarkets, food banks, community kitchens and community gardens<sup>(48)</sup>. No significant associations emerged, even after considering severe food insecurity, or when using continuous distances or a shorter cut-off (1 km or less). Other null results included perceived adequacy/number of local food stores in three studies<sup>(37,48,49)</sup> and perceptions/estimations of high food prices in one study<sup>(49)</sup>.

### **Socio-economic environment**

Three out of three studies that investigated rent prices at the area level estimated a positive association with food insecurity<sup>(38,47,51)</sup>; although two of these were conducted by the same lead author. One study uncovered a positive association between an index of area deprivation and food insecurity<sup>(42)</sup>, while one study that used a similar index<sup>(54)</sup> and another that focused on poverty level<sup>(47)</sup> did not find any significant associations. Bernell *et al.* (2006) also examined percentage of the county unemployed and average wage, with null results<sup>(38)</sup>.

### **Discussion**

Among the studies included in the present review, a range of place factors were examined. Summarizing the results by type of place factor revealed a potential protective effect of rural living on food insecurity that may or may not be applicable among older adults. Studies on the quality of the social environment, namely social capital, also suggested a possible protective role; however, half found no significant associations, while

those with positive findings tended to focus only on low-income populations. Among studies investigating the food and socio-economic environments, relationships were less clear.

### **Potential limitations of included studies**

As a result of conducting this critical review and from the perspective of furthering knowledge about place and food insecurity, consideration of some of the limitations of the existing research is warranted. The most common limitations are summarized below, but see also the last column in Table 1 for unique study concerns.

The most obvious limitation of this body of research is the exclusive reliance on the cross-sectional study design. Although some physical environmental characteristics do take some time to change, social environmental characteristics may not take as long; longitudinal studies can account for these changes. In addition to taking into account changes in place factors, longitudinal studies can also account for and provide insight into how food insecurity changes over time. This increases our understanding of the problem and increases power to detect significant differences between variables. In longitudinal studies, subjects act as their own controls; thus, confounders that are unobserved and do not change over time can be controlled for, which increases the study's robustness.

Almost half of included studies used the eighteen-item or six-item USDA Food Security Scale and recommended cut-offs to define food insecurity. Benefits of using this measure include rigorous development and validity/reliability testing that has spanned a number of years<sup>(8)</sup>, as well as increased comparability across studies. Many studies, on the other hand, relied on single question measures, often for secondary data analyses of large population-based surveys. While these questions were largely based on previously validated work and/or derived from items in the USDA Food Security Scale or the Radimer/Cornell measure of food insecurity, they are not likely to measure food insecurity comprehensively and make it difficult or impossible to compare across studies<sup>(8)</sup>. Given that measures with many items are burdensome to respondents, especially so when administered as part of a large-scale population-based survey, the USDA Food Security Scale six-item short form may be an ideal candidate for more widespread use in future intervention and observational studies, instead of simply relying on single item measures. The shorter length of the questionnaire does not appear to affect its discriminatory power<sup>(55)</sup>. However, this measure does not directly ask about child food insecurity and cannot measure the most severe form of adult food insecurity, where children's intake is likely to be reduced<sup>(56)</sup>. In addition to single item measures, some studies used multiple questions as more than one outcome. This can increase the likelihood of estimating a significant association by chance and makes

overall interpretation of results more difficult. Analysing types or severity of food insecurity (e.g. household, adult and child) as individual outcomes or in multinomial logistic regression analysis, without *a priori* hypotheses and context, also makes results difficult to interpret.

Many studies did not control for sex of the respondent. Given societal gender roles, men and women often perceive situations differently. For example, females are generally responsible for food management in the household and therefore would likely be more attuned to problems with food security. Gender differences may also affect how the surrounding environment is perceived. Some studies that did not adjust for sex selected respondents who were primarily responsible for buying and cooking food in the household, which could partially adjust for this difference (e.g. Kirkpatrick and Tarasuk (2010)<sup>(48)</sup>). Additionally, it would be less concerning if there was very little variability in the sex of the respondent; however, no studies appeared to discuss this. In addition to not adjusting for sex, several studies did not adjust for area-level income, SES or some other measure incorporating relative area disadvantage. Thus, these studies cannot provide information on the potential for area disadvantage to confound associations between the place factors and food insecurity, or the possibility that the place factors mediate the effects of area disadvantage.

There was much heterogeneity among measures of the food environment and clearly there is a lack of a critical mass of studies examining the same or similar features in order to make any type of conclusions about the potential effect of the food environment on food insecurity. Additionally, there needs to be more discussion about how some of these measures were derived, particularly with respect to respondent perceptions; questions seemed vague, not always tested, and thus open to bias as an explanation for findings.

Interestingly, area SES was underexplored, perhaps because a large proportion of included studies (39%) limited populations to low-income or certain ethnic groups, or because of the well-known link between individual income/SES level and food insecurity. Nevertheless, there still may be some variability in area SES to explain differences in individual food security status, even among low-income populations. Certainly, among population-based samples, area SES should continue to be explored. And as discussed previously, in any study on place and food insecurity, area SES should be considered as a potential confounder, or even an effect modifier, when analysing other features of place.

Sample selection, along with generalizability, should be kept in mind when interpreting the results of the present review. Limiting sample populations to a particular demographic subgroup reduces generalizability of the results. Generalizability is especially problematic when attempting to synthesize information from a relatively new area of research, with few studies, and even more so when most of

those studies are conducted in one country; here the reader is cautioned that most studies were conducted in the USA. Once a larger evidence base is established, future reviews should conduct sensitivity analyses to determine potential differences among population subgroups. Limiting to particular subgroups also makes it difficult to detect important significant differences, due to less variability within the sub-population sample than in a population-based sample.

Of the individual-level studies that relied on some form of cluster sampling method, not all adjusted for potential correlations between individuals within a cluster, which could bias the results from statistical tests of association. Additionally, sampling frames were sometimes based on telephone lists. This likely resulted in an underestimation of food insecurity, as having a telephone land-line is related to income, which is related to being food insecure. Lower study power and decreased ability to generalize are likely outcomes of this sampling method. Selection bias may also result if under-coverage is related to the place characteristic(s) under study. Selection bias is also a concern when certain participants are excluded because of missing data. A discussion of the impact of missingness was lacking overall in this body of research.

While the results of the review suggest a potential protective effect of rural living, the measures of living location were generally crude, encompassed large areas (counties), were heterogeneous and often were not the main interest of the study. Given this, one can only speculate as to what it is about rural environments that may protect against food insecurity. More precise definitions and comparisons may yield different results.

Finally, exposures may not be the same for individuals living in the same area. For example, living in a disadvantaged area may not actually be an important exposure for a particular individual, depending on his/her own compositional factors such as income and car ownership, as well as interacting contextual factors such as social capital, high-income neighbourhoods located close by or availability of subsidized school meals, to name a few. Given the complexities of exploring these types of interactions, it is not surprising that none of the included studies conducted this analysis. A handful of studies did discuss car ownership and/or other transportation methods<sup>(37,48,49)</sup> and some did adjust for other place factors in multivariable models. A relational understanding of place that takes into account spatial and temporal mobility has been recommended in the literature<sup>(57)</sup> and is likely applicable in this area of research, at least with respect to the development of theory and study design.

### **Limitations of the present review**

In addition to the limitations of included studies, the review itself has a number of limitations that may have affected which studies were and were not included. The grey literature was not searched; another recent



review on environmental characteristics and food insecurity uncovered several papers that were not published in scientific journals<sup>(36)</sup>. These studies, for the most part, did not examine place as defined in the present review and so would not have been eligible for inclusion. Conference proceedings and abstracts as well as dissertations were not included; it is therefore possible that studies with null or non-intuitive findings were not included. Hand-searching the reference lists of included articles was conducted, but not for entire journals in the field, and only one person (M.A.C.) selected articles based on *a priori* eligibility criteria and abstracted the data. Thus, pertinent studies may have been missed. Studies may have also been missed if they analysed a place factor which was not part of the main objective(s) (e.g. it would not have been evident from the title or abstract and then potentially screened out). The review did not focus on household environments or the broader socio-economic environment, both of which may play a role in food insecurity<sup>(58)</sup>.

### Recommendations and conclusions

This critical appraisal and synthesis of published research allowed for the formulation of recommendations for future research studies, which should help to drive the field forward. These are detailed below.

Sampling methods should avoid using telephone lists to recruit participants whenever possible. Some variant of cluster random sampling may be most appropriate, where surveys are administered in person. Population-based samples that do not focus exclusively on low-income and/or largely rural populations may be most informative, especially from a policy-making perspective. In order to reduce respondent burden, make use of a solid evidence base and avoid basing measurement of food insecurity on one question, authors of future studies may consider using, at the very least, the USDA Food Security Scale six-item short form. This will help to increase comparability across studies. Finer grained definitions and a specific focus on place are also needed; especially with respect to living location. Including housing/residential density, land-use mix, farming, social capital, as well as exploring how car ownership and other transportation methods can influence food insecurity in the context of rural and urban living, is important. Well-conducted longitudinal observational studies are preferred to cross-sectional studies, and testing for interaction with the place variables of interest could help to make results more robust and informative. Furthermore, adjustment for sex as well as other confounders, such as individual and area SES, is necessary to reduce bias in the resulting associations between the place factors and food insecurity.

Finally, community-based initiatives, such as community gardens, were not evaluated in the present review because none included measures of individual/household food

insecurity as outcomes. Studies that were screened out consisted mostly of process evaluations of single programmes. This area of research could benefit immensely from applying more rigorous experimental and quasi-experimental methods and evaluating changes in individual/household-level food security status of area residents. Randomized community-wide interventions that are not necessarily programmatic in nature (e.g. changes to the physical environment) are also important areas for further research. Place and food insecurity is a fairly new and evolving area of research. Given that everyone should have access to healthy, acceptable food, regardless of income, and that developing redistributive income and other equitable policies is socio-politically complex, time consuming and contentious in some high-income democratic countries, focusing on how the immediate local environments may improve or inhibit food security could be a potentially fruitful area of research, especially in today's economic climate. The literature synthesized in the present review points to rural living as a potential protective factor, although a number of methodological limitations prevent any decisive conclusions from being made at this time. Recommendations have been formulated and presented in an attempt to improve the quality of research in this field.

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### Supplementary Materials

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