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A systematic review of the Australian food retail environment: Characteristics, variation by geographic area, socioeconomic position and associations with diet and obesity

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Summary

There is strong support across multiple sectors for the implementation of policies to create healthier food environments as part of comprehensive strategies to address obesity and improve population diets. The existing evidence base describing food retail environments and their relationship with health outcomes is limited in several respects. This systematic review examines the current evidence regarding food retail environments in Australia, including associations with diet and people with obesity, and socioeconomic and geographic disparities. Three databases were searched and independently screened. Studies were included if they were undertaken in Australia and objectively measured the food retail environment. Sixty papers were included. The broad range of methodological approaches used across studies limited the ability to synthesize the evidence and draw conclusions. Results indicated that there is some evidence that disparities exist in food retail environments across measures of socioeconomic position and geographic area in parts of Australia. Overall, there were inconsistent findings regarding the association between the healthiness of food retail environments and diet or people with obesity. Findings support previous calls for standardized tools and measures for monitoring the healthiness of food retail environments. This is imperative to inform evidence-based policy and evaluation in this critical component of recommended obesity prevention strategies.

KEYWORDS

food environment, food retail, nutrition environment, obesity

1 | INTRODUCTION

The recently published Lancet Commission on the Global Syndemic of Obesity, Undernutrition and Climate Change identified malnutrition in all its forms, including obesity, as the leading cause of poor health globally.[1] Between 1975 and 2014, the world's population became, on average, more than 1.5kg heavier each decade.[2] In 2014, estimates indicated that 30% of the global population were people with overweight or obesity (>2.1 billion people) with a global economic burden of US $2.0 trillion through health care expenditure, lost productivity and economic growth, mortality and permanent disability.[3] In 2014 to 2015, approximately 63.4% of Australian adults (aged >18 years) were estimated to have overweight (35.5%) or obesity (27.9%); in children (aged 5-17 years) one in four children were estimated to have overweight (20.2%) or obesity (7.4%).[4,5] The burden of overweight and obesity is higher for Australia people in regional and remote areas, for males, and for females in areas of socioeconomic disadvantage.[4,6]

The World Health Organization (WHO) has set a goal to halt the rise in obesity by 2025 to 2010 levels globally,[7] though current trends suggest that it is unlikely that Australia will meet this target.[2]

The WHO along with the Lancet Commission recommend strengthening national food and nutrition policies on a global scale by prioritizing, amongst other strategies, the implementation of policies aimed at improving the provision and availability of healthy foods.[2]

Due to the complex and multifaceted nature of obesity, a systems approach to prevention is recommended.[8] A systems approach emphasizes that whilst at an individual level energy imbalance between calories consumed and calories expended leads to increased fat accumulation; numerous societal and environmental drivers outside the individual play a role in the obesity epidemic.[9] Swinburn et al[10] defines a "driver" of the obesity epidemic "as an environmental factor that has changed substantially during the past 40 years (coinciding with the upswing of the epidemic), is global in nature (affecting almost all countries with enabling economic conditions), and is rapidly transmissible (in view of the near simultaneous nature of the epidemic across countries)." By this definition, the food system, which saw significant change in Australia and other high-income countries commencing in the 1960s to 1970s, can be viewed as a driver of the obesity epidemic.[10] Research on environmental food system changes and obesity indicates increased food energy supply, accompanied by increased energy intake have been shown to partially explain the increases in obesity rates around the world. Bleich et al[11] examined changes in energy availability in the food supply in member countries of the Organization for Economic Cooperation and Development between 1961 and 2002 demonstrating that for the majority of countries, increases in obesity can be explained by increased supply, and consequent consumption of calories. The lower cost of refined grains, added sugars and fats, has meant that diets high in these energy dense nutrient poor (EDNP) foods were more affordable than diets comprising of whole foods such as fruit, vegetables and lean meats.[12] In Australia, the trends indicate that there is a general shift away from home cooking towards eating meals out of home and fast foods.[13] The most recent *Food demand in Australia: Trends and issues report* reported increases in the amount of money spent on meals and fast food as a proportion of total food expenditure from 25% in 1988 to 1989 to 34% in 2015 to 2016.[13] Private entities such as global food companies (eg, fast food and supermarket chains) have experienced rapid growth during the nutrition transition and have reaped the benefits of economic growth, and this continues.[10] Using ever improving marketing platforms, global food companies perpetuate growth through implementing expansive marketing campaigns using persuasive techniques encouraging increased purchasing and consumption of EDNP foods.[14]

Conceptual frameworks for moderating the environmental supply-side drivers of obesity highlight the potential cost-effectiveness, effectiveness and sustainability of evidence-based policy action.[14,15] Nevertheless, individual-level programmes and education-based interventions that work to counteract effects of obesogenic environments (rather than interventions designed to change the nature of obesogenic environments themselves) prevail.[14-20] Reluctance from policy makers to regulate the market is largely due to the complexity and high level of political difficulty faced by decision makers, whom are heavily influenced by the corporate power of "Big Food" companies and preference for self-regulatory practices.[14,21] Swinburn et al[1] highlights that on a global scale, many countries' efforts to develop and implement national nutrition policies to reduce obesity and undernutrition and improve the environmental sustainability of food systems have failed due to pressure exerted from strong food industry lobby groups. As such, debate is ongoing as to how much individuals are personally responsible for the foods they consume when environmental attributes serve to undermine efforts to make a healthy choice.[22]

For the purposes of this review, food environments are defined as "the collective physical, economic, policy and sociocultural surroundings, opportunities and conditions that influence people's food and beverage choices".[14,16] INFORMAS, an international network of public interest organizations and researchers that aims to monitor and benchmark food environments globally to reduce obesity and noncommunicable diseases and their related inequalities, conceptualizes the food environment as being comprised of seven inter-related "impact modules" including (a) food composition (ie, nutrient composition of foods), (b) food labelling (ie, health-related labelling of foods), (c) food promotion (ie, nature and exposure of the population to promotion of healthy and unhealthy foods), (d) food provision (ie, healthiness of foods provided within different settings), (e) food retail (ie, healthiness of food available within communities and retail outlets), (f) food price (ie, relative price and affordability of healthy/unhealthy foods, meals and diets) and (g) food trade and investment (ie, impact of agreements on healthiness of food environments).[16] The INFORMAS conceptual model aligns closely with other conceptualizations of the food environment, such as that proposed by Glanz et al.[15] This review reports on the food retail component of INFORMAS only, which includes the food and non-alcohol beverages available within food retail outlets, and the type of food retail outlets available within communities.

In Australia, as occurs in other developed countries and increasingly in developing countries, food retail environments are saturated by EDNP foods, which are readily available, relatively inexpensive and heavily promoted.[16,17,23,24] However, evidence of a causal relationship between the food retail environment, diet and obesity is limited by heterogeneity of methods and measures across studies resulting in an inability to synthesize evidence and build an evidence base for policy development.[20,25-30] In Australia, this is further limited by the small proportion of studies that could translate into evidence-based policy in an Australian context.[29,31-33] Whilst evidence from Australia and other developed nations is lacking, evidence from the United States supports a moderate association between the food retail environment and diet[29] and people with obesity.[30,32] The ability to generalize findings from studies in the United States to other countries is limited by the geographic differences in the prevalence of people with obesity and variations in the social, cultural, economic and regulatory processes that govern food.[20,32,33] Recent research examining food retail environments in the United States, Canada and New

Zealand supports the premise that food environments are measurably different across countries.[28-30,34] In the United States, "food deserts" (areas with limited access to healthy food) are evident in areas of disadvantage, whereas in Canada and New Zealand areas of disadvantage are characterized by the abundance of food outlets providing EDNP foods, often termed "food swamps".[30,34,35] Currently, no substantive reviews of the food retail environment exist for developed countries outside the United States,[30] Canada[35] or New Zealand.[34]

The purpose of this study was to conduct an Australian-specific systematic review to examine the available literature providing descriptive and empirical evidence on the healthiness of Australian food retail environments; (a) methodological approaches used to measure food retail environments and the healthiness of them; and, to synthesize the evidence on the variation in the healthiness of food retail environments by (b) measure/s of socioeconomic position (SEP) (ie, education, employment and income) and (c) geographic area (ie, metropolitan, urban and rural) and associations between food retail environments and (d) diet (ie, fruit and vegetable consumption and fast food consumption) and/or (e) obesity (ie, area level or individual measures of prevalence/odds of people with obesity using measures such as body mass index (BMI) $\geq$ 25 or central obesity).

2 | METHOD

This systematic review was registered with PROSPERO (ID: CRD42018095356) on 24 August 2018.

The review is a subset of a broader review in which the search strategy was developed to identify papers examining four of the seven food environment impact modules identified by INFORMAS: (a) food retail, (b) food prices, (c) food promotion and (d) food labelling.

2.1 | Search strategy

The search strategy was developed by building on an earlier systematic review, which examined the association between the food environment and people with obesity in Canada and the United States.[27] In this study, the literature search was conducted on 24 August 2018 in EBSCO, Embase and Web of Science and was adjusted for each database and limited to original peer-reviewed journal articles published in English. The search terms used can be found in SF1.

Search results were imported using Endnote X8, returning 4,992 unique papers (duplicates removed). Using Systematic Review Software *Covidence*,[36] two reviewers (C. N. and C. S.) independently reviewed studies by title and abstract first, followed by screening full text, which excluded a further 4,570 studies. The remaining 422 studies were independently screened by full text for eligibility by C. N. and C. S. with 158 identified as eligible (Figure 1). Any discrepancies through the review process were resolved through consensus of both reviewers. An additional search was undertaken prior to submission limited to papers published between March 2018 and 1 March 2019; two additional papers were identified for inclusion.

Studies were included if they were (a) published between 2002 and 1 March 2019, (b) measured food environments in Australia and (c) objectively measured at least one aspect of the four INFORMAS food environment impact modules. The decision to include studies published from 2002 onwards was selected as in January 2002 WHO conducted a global expert consultation and review of the scientific evidence providing recommendations for diet, nutrition and the prevention of chronic diseases, highlighting the complex relationship between the environment and health.[37] Studies were excluded if they were a review, editorial or conference abstract; related exclusively to availability of alcohol; used only perceived (rather than actual) measures; or reported only associations between behaviours or attitudes and the food retail environment (eg, food purchasing behaviours). To enable comparison, eligible papers (n=160) were grouped according to the four INFORMAS impact modules of food retail (n = 60), food prices (n= 33), food promotion (n = 50) or food labelling (n = 26), with 21 papers reporting results across more than one module.[16] Due to the number of studies identified, research outputs for each INFORMAS impact module were reported separately. In this review, only papers under the food retail impact module were examined.

2.1.1 | Data extraction—Australian food retail environment

This systematic review examines a complex set of questions regarding the food retail environment. Significant variability between studies was expected, and as such, a meta-analysis was not plausible. As with other reviews examining aspects of the built environment in relation to public health, results are described in the form of a narrative synthesis.[38,39] Each of the 60 identified studies were categorized into five subgroups based on the overall aim of this review: studies that (a) described the healthiness of food retail environments and (b) how they varied by geographic locations and (c) measures of SEP; and, examined the association between healthiness of food retail environments and health-related outcomes[3] diet and[4] obesity. The following data were then extracted: year published; geographical location within Australia; study design; aims; methods and measures; exposure and outcome variables; data analysis approach; confounders controlled for; descriptive statistics; associations between the food retail environment and measure/s of SEP, geographic area, diet and/or obesity; and key finding(s). Based on the literature and the expertise of the research team, it was hypothesized that healthier food retail environments would be associated with higher measure/s of SEP and living in locations closer to metropolitan areas,[31,35] healthier diets and decreased prevalence of people with obesity.[15] Where studies examined additional aspects of the built environment (eg, walkability), data were only extracted in relation to the food retail environment. Where analysis included adjustment for confounders, only adjusted results were extracted. Data extraction was completed by the lead researcher (C. N.); a second reviewer (E. R.) extracted data from a 10% subsample (n=6) of papers, which were checked for agreement which reached 100%.

A quality assessment of included papers was not undertaken due to the absence of a standardized quality assessment tool or recognized

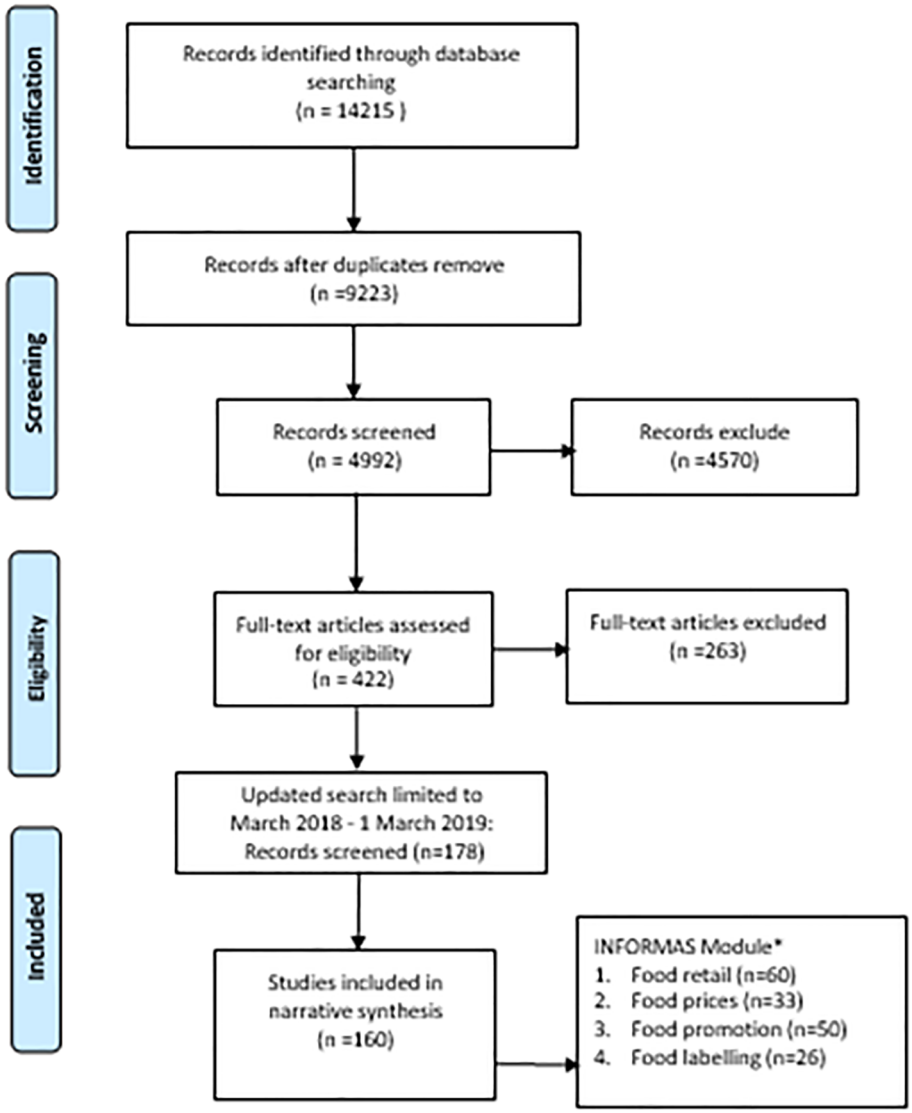

FIGURE 1 Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) flowchart *21 papers reported in more than one INFORMAS impact module

methodological "gold standard"[29] in the realm of food retail environment research.

3 | RESULTS

3.1 | The extent of available Australian literature and methodological approaches

Sixty eligible studies examined characteristics of the food retail environment. Table 1 provides a snapshot of associations reported in each paper examining the food retail environment, including (a) variation by SEP measure/s, (b) variation by geographic area, (c) associations with diet and (d) associations with obesity. Studies reporting food retail environment descriptive information with no statistical analyses are reported separately in SF2. When studies reported results in more than one focus area, each finding was extracted and discussed separately. There were 70 unique research questions extracted from 60 papers. Since 2002 until 2019, there has been a steady increase in the number of papers examining the food retail environment in each focus area, with a surge in papers examining variation between the food retail environment and SEP between 2006 and 2009 (Figure 2).

Most studies were undertaken in Victoria (n=29), seven studies from South Australia, six each from New South Wales, Western Australia and Queensland, two from the Northern Territory and no studies from Tasmania. Metropolitan areas were the focus of most studies (60%). Four studies considered the food retail environment at the national level.[52,78,86,89] All studies were observational with 41 cross-sectional, five longitudinal (two of which used only baseline food retail environment data alongside longitudinal health measures), and the remaining studies identified as ecological (n=2), case studies or census audit (n=9), or mixed/multiple methods (comparison of historical price data with measured price data; examination of food retail and associations with BMI across urban areas contextualized through qualitative

TABLE 1 A snapshot of associations reported in each paper

Food Retail Variable Measured	Null	Positive	Negative	Mixed
Variation by socioeconomic position (n=23) **Hypothesis: healthier food retail environments in areas with higher measures of socioeconomic position*				
In-store healthiness: Healthy food basket availability; shelf length dedicated to healthy and/or unhealthy food	40-45	46-48		49
Healthiness of food outlets: Density/presence/proximity to home and/or within a defined geographic area	50,51	48,52-58		59-61
Healthiness of vending machines products at train stations				62
Variation by geographic area (n=11) **Hypothesis: healthier food retail environments in locations closer to metropolitan areas*				
In-store healthiness: Availability of a healthy food basket and/or junk food basket; shelf space, end of aisle and checkout space dedicated to healthy and unhealthy food		47,63,64		49
Healthiness of food outlets: Density/presence/proximity to home and/or within a defined geographic area		59,65	57	66-69
Association with diet-related outcomes (n=12) **Hypothesis: healthier food retail environments would be associated with healthier dietary consumption.*				
Supermarkets, fruit and vegetable retailers: Density/presence/proximity to home and/or within a defined geographic area	70-72			73
Proxy healthy food (supermarkets and/or greengrocers) and fast food outlets: Density/presence/proximity to home and/or within a defined geographic area	59			74-76
Measure of healthiness of food retail examining the ratio of healthy to unhealthy food outlets or overall healthiness of all food outlets: Density/presence/proximity to home and/or within a defined geographic area		77		78
Fast food outlets; takeaways and restaurants: Density/presence/proximity to home and/or within a defined geographic area	79			61
Association with obesity or weight-related outcomes (n=13) **Hypothesis: obesity prevalence would be lower in healthier food retail environments*				
Supermarkets, fruit and vegetable retailers: Density/presence/proximity from home residence	70			
Proxy healthy food (supermarkets and/or greengrocers) and fast food outlets: Density/presence/proximity to home and/or within a defined geographic area	80			59,60,69,81,82
Measure of healthiness of food retail examining the ratio of healthy to unhealthy food outlets: Density/presence/proximity from home residence		83		
Fast food outlets; takeaways and restaurants: Density/presence/proximity to home and/or within a defined geographic area	84,85	86	87	
Healthiness of remote Indigenous community stores	88			

Note. Null = non-significant association between variables of interest; positive = significant association in the hypothesized direction; negative = significant association opposite to that hypothesized; mixed = signification association in the hypothesized direction or the opposite direction or non-significant association.

interviews; and, an impact evaluation of an intervention to increase access to fruit and vegetables*baseline food retail measures extracted only) (n=3).

Significant heterogeneity was observed across all studies particularly regarding the food retail variables examined (Table 2), how they were measured (Table 3), and how a healthy food retail environment

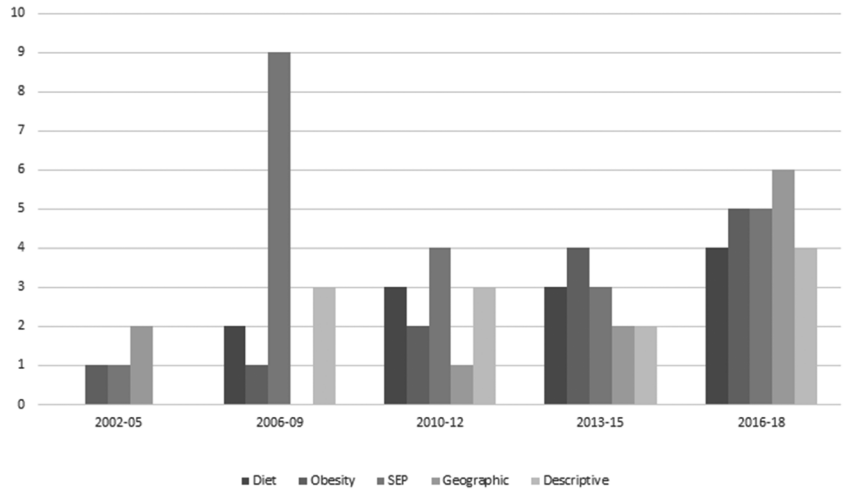

FIGURE 2 The number of Australian studies reporting results over time for the topics of interest including: variation in food retail across geographic areas and socioeconomic position (SEP), food retail in association with diet and people with obesity, and studies that reported food retail descriptive statistics only

TABLE 2 Food retail outlet types examined in association with diet, obesity, and variation by area-level socio economic position and across geographical areas

	Association Between Healthiness of Food Retail Environments and Health-Related Outcomes		Variation in the Healthiness of Food Retail Environments	
Combinations of Food Retail Outlet Types Examined in Each Study	Diet	Obesity	Socio-economic Position	Geographic Area
All supermarkets/all supermarkets and greengrocers in-store			40-42,46,47,49,50	47,49
In-store: Supermarkets, greengrocers and butchers			43,44	
In-store: Supermarkets, greengrocers and convenience stores			45	
Supermarkets	73			
Supermarkets and Indigenous community stores				66
Chain supermarkets			53	
Chain supermarkets and chain fast food	59	59,69	54,59	59,69
All supermarkets and greengrocers	70			63
Chain supermarkets and greengrocers	71,72,74		48	
Greengrocers, chain fast food and chain supermarkets	75,76	60,80	60	
Greengrocers, fast food and all supermarkets				67
All supermarkets, greengrocers and fast food		81		
Chain fast food		84,86,87	52,55,56	57
Fast food (chain and independent)			58	
Fast food and takeaway	61		51,61	
Supermarkets, greengrocers, fast food and takeaway				68
Takeaway and restaurants		85		
All/most food outlets	77-79	82,83,88		65
Most popular food store				64
Vending machines			62	

was defined. The most common food retail environment exposure variable examined related to the supermarket setting (n=31 studies). Nineteen studies measured access to supermarkets, being defined as the density/proximity/presence within a defined area, with 63% considering only chain supermarkets. Eleven studies analysing variation by measure/s of SEP or geographic area examined supermarket in-store availability of foods using a standardized healthy food basket

TABLE 3 Measures of density/proximity of food retail outlets used within studies

	Association Between Healthiness of Food Retail Environments and Health-Related Outcomes		Variation in the Healthiness of Food Retail Environments	
Measures of Density/Proximity of Food Retail Outlets Used Within Studies	Diet	Obesity	SEP	Geographic Area
R 400m		81		
R 800m	59,61,71,74	59,69,80-82	59,61	69
R 1000m	59	59,69,83	59	69
R 1600m	59	59,69,81	59	69
R 2km	59,71,72,78,90	59,60,69,80,84,87	48,60	69
R 3km	59,71,75,76	59,69,80,82,84	56,59	
R 3.2km		81		
R 5km		84		
Proximity from residence to closest food retail outlet	59,61,70,72-76,78	59,60,69,70,82,87	48,56,60,61	69
Buffer surrounding School/route to school (range 0.4 to 3km)			57,58	57,61
Audit 3-km buffer surrounding McDonald's site	79			
1-km buffer around population weighted centroid				59
2.5-km buffer around geographic centroid			51	
800-m street network buffer around Neighbourhood Activity Centre				65
Geographic unit ie. suburb, statistical area 2, state and Indigenous communities)	77	83,85,86,88	48,51-55,57	57,67,68

Note. R: buffer distance surrounding participant home residence.

Abbreviation: SEP: socioeconomic position.

audit tool, which monitors trends in the affordability and availability of a basket of food based on recommendations from the Australian Healthy Eating Guide[90] and/or by measuring shelf/bin space dedicated to core and non-core foods. Twenty studies examined access (density/proximity/presence) to fast food outlets in a defined area, 78% (n=15) of them examining only chain fast food outlets. The source of data regarding the food retail environment, such as food outlet type and location, was not reported in 19 studies. Over half (n=39) of studies sourced secondary food retail data (ie, presence, name and location of a food retail outlet) and most studies cross checked these secondary data sources with online data searches. Seven studies also undertook some form of ground truthing (ie, field audit and Google Street View). Secondary data sources included paper-based or online local business directories (eg, Yellow Pages and White Pages), local or state government food retail databases, company websites and purchased commercial datasets (eg, from Sensis Pty Ltd the data custodians for the Yellow Pages).

Sixteen of 70 research questions examined in store availability of healthy food in food retail environments. Eleven of these used a healthy food basket/audit or shelf length measurement approach to examine variation by measures of SEP.[40-47,49,50,91] Five studies used a similar approach to examine variations be geographic area.[47,49,63,64,66] Of the remaining studies, numerous spatial measures of food retail environments were used (Table 3). Twenty studies used a *person-centred approach*, enumerating food sources around the home residence of a participant within a defined area (usually a circular road network or pedestrian buffer around the home address ranging from 400m to 5km). Fifteen (75%) of these studies also measured proximity of food outlets to a participants home residence. Twenty-three studies took a *built environment-focused approach*, examining the food retail environment within a geographically defined unit (eg, suburb, Indigenous community and state). Four studies examined food sources around schools and *en route* to school. One study examined the healthiness of vending machines at train stations.[62]

3.2 | Studies describing variations in food retail environments

3.2.1 | Australian food retail environment variation by measure/s of socioeconomic position

Twenty-three studies examined whether the food retail environment varied significantly by measure/s of SEP (Summary table available in SF2). Studies examining variation by SEP consistently used the Australian Bureau of Statistics Socioeconomic Indexes for Areas (SEIFA) as a measure of SEP.

In-store food retail

Eleven reported on the in-store food environment,[40-47,49,50] one of which also examined access to food retail outlets.[48] Seven studies examined availability of a healthy food basket,[43,44,49] fruit and vegetables,[45,50] or a combination of proxies for healthy/core and unhealthy/non-core foods[40,48] by area-level measure/s of SEP, with six studies reporting no significant variation.[40,42-45,50] In contrast, in a convenience sample of remote, accessible and highly accessible areas defined by the Access/Remoteness Index of Australia found areas of disadvantage lacked variety in fruit and vegetable availability compared with areas of greater advantage.[49] These findings were further supported by Ball et al,[48] who found that availability of fruit and vegetables varied by SEP, favouring more advantaged neighbourhoods, although availability of ENDP foods did not vary.

Three studies measured variation in healthiness of food retail environments by examining in-store shelf-length or bin size dedicated to displaying healthy and unhealthy foods across areas of differing SEP[41,46] and one by area-level SEP and geographic area.[47] Thornton et al[41] found no significant variation by area-level SEP, whereas Cameron et al[46,47] found that supermarkets in high SEP areas and urban areas offered healthier food, compared with urban fringe, rural and non-metropolitan areas.[47]

Access to food retail outlets

Thirteen studies examined access to food outlet types, 12 by area-level SEP[48,51-59,61,62] and one study examined access to food outlet types and how this varied using an individual measure of education as a proxy for SEP.[60] Eight studies found significant associations in the hypothesized direction; that is, more disadvantaged areas had significantly more unhealthy food retail environments[48,52-58]; four studies reported mixed findings[59-62]; one study reporting non-significant results.[51]

Three studies examined children's food retail environments examining food sources around children's homes and *en route* to school[61] by area-level SEP, two studies examining food sources in geographic units containing schools.[57,58] One study undertook an analysis of vending at train stations across area-level measures of SEP reporting that mean numbers of items in vending machines at train stations was higher in high-SEP areas, whilst the mean number for healthy items was higher in mid-SEP and high-SEP areas.[62]

Five studies found that more disadvantaged areas had significantly greater exposure to food outlets considered unhealthy.[51,52,54-56] Fast food outlets were found to be more proximal to participants' residence[51,54,56] and of greater density[55,56] in areas of low SEP. One study reported that postal districts in the highest-income areas in Melbourne (Victoria) had no fast food outlets.[55] On a national level, a study found that areas with a McDonald's fast food outlet had significantly lower area-level SEP scores than those without.[52]

Five studies found that more advantaged communities had significantly greater access to supermarkets and greengrocers.[48,53,54,59,60] Abbott et al,[60] using education as a proxy of SEP, found that women who had a high school certificate or above had greater access to supermarkets and greengrocers and fast food outlets also. Similarly, Murphy et al[59] found that adults that lived in more disadvantaged areas lived closer to both supermarkets and fast food outlets.

Three studies found that odds of exposure to fast food outlets was higher around schools[57,58] and around children's home

residence in more disadvantaged areas.[61] However, Timperio et al[61] found that children in high-income areas had greater access to fast food and takeaway outlets *en route* to school, and medium-income areas had the lowest density of fast food and takeaway outlets within 800m of home.

3.2.2 | Australian food retail environments variation by geographic area

Eleven studies examined variation in food retail environments across different geographic areas (eg, metropolitan areas vs rural areas) by measuring access (proximity/density/presence) to store type/s[59,65,67,69] or in-store food availability or proportional shelf-space of food types[47,49,63,64] or both[66,68] (Summary table available in SF3). One study examined the density and proximity of chain fast food outlets surrounding schools across urban and rural areas.[57] Studies that examined variation in food retail by geographic area were less consistent in the way they measured the food retail environment. Four reported on differences in access to food retail outlets across metropolitan suburbs[59,65,68,69] or by remoteness.[57,66,67] Three studies examined geographic variation in access to a healthy food basket, across rural towns[63] and by level of remoteness.[49,64] Cameron et al[47] was the only study to examine proportion of shelf space/bin size dedicated to food types across geographic (metropolitan inner to outer) areas.

Four Melbourne studies found access to supermarkets decreased from the inner to the outer fringe suburbs[59,65,68,69]: one reporting this was also the case for fast food[69] and another reporting no significant variation in fast food and takeaway outlets by geographic area.[68] Comparing rural and urban areas in Victoria, Thornton et al[67] found that urban areas had greater spatial density of fast food outlets, supermarkets and greengrocers, but rural areas had more supermarkets per '000 population. Primary and secondary schools in major cities were found to have fast food outlets in closer proximity and higher density within 0.5 to 2km compared with schools in inner and outer regional areas.[57] Cameron et al[47] found significant variation across areas, with inner-urban stores being healthier in comparison to urban-fringe and rural/non-metro stores despite more chocolate at check outs.

In Western Australia, chain supermarkets were found to only service areas of high population density, with independent stores servicing areas of lower population density and community stores providing essential services in remote areas.[66] In rural South-West Victoria where a large retail chain supermarket was present, the complete healthy food basket was more likely to be available compared with areas where only an independent supermarket or food store was present.[63] In line with these findings, with increasing remoteness the variety of fruit and vegetables tended to decrease in New South Wales[49] as did the number of nutritional choices available in Queensland.[64] Conversely, Ball et al[48] and Burns et al[63] found that the availability of EDNP foods did not vary by geographic area in Victoria.

3.3 | Food retail environments in Australia—Other characteristics

Several studies (n=11) reported on the food retail environment in an Australian context but did not undertake an analysis regarding variation based on a geographic area or SEP, or associations with diet or people with obesity (summary table available in SF3).

Innes-Hughes et al[92] found that in rural areas of New South Wales whilst most residents were within 4km of a supermarket offering healthy foods, when examining supermarket and takeaway access, residents in two of the towns were closer to a takeaway outlet (offering no healthy food options) than a supermarket (proxy for healthy food options). In a rural local government area in Victoria, Whelan et al[91] also found that food service outlets (n=27: cafes, fast food, takeaways, pubs, restaurants and bakeries) with limited healthy choices were more predominant than food stores (n=11: general stores, supermarkets). Also, in rural Victoria, Palermo et al[93] found in two local government areas where no retail food outlet or supermarket was present that the range of fruit and vegetables available was very limited.

In a remote Aboriginal community, Lee et al[94] found the availability of healthy and unhealthy foods in community stores increased over time. In two studies, Brimblecombe et al[95,96] quantified food resources available to an Aboriginal community on an island in Arnhem Land and found that access to fruit and vegetables was limited, whilst independent takeaway stores were more abundant and operated more regularly. Dixon et al[97] examined end-of-isle displays and checkouts in Melbourne supermarkets and highlighted a very high proportion of EDNP foods.

Two studies described characteristics of the food retail environment in Perth in association with walking, reporting food retail environment descriptive statistics only.[98,99] Oaken et al[100] reported on the proportion of shelf-space dedicated to foods in food outlets around schools in a low SEP area of Queensland and found that greater than 75% of food outlets were unhealthy, and 88% of shelf-space corresponded to unhealthy food. Thornton et al[89] described how the availability of snack foods in supermarkets varied internationally across eight developed nations including Australia and reported that Australia had the greatest aisle length dedicated to soft drinks.

3.4 | Studies examining the association between healthiness of food retail environments and health-related outcomes

All studies that examined the association between the food retail environment and diet and/or people with obesity used data collected from participants linked to spatial food environment datasets.

3.4.1 | Australian food retail environments and diet

Twelve studies examined associations between food retail environments and diet (Table 4). Approaches to measure the food retail environment were heterogeneous across studies (Table 2). Outcome measures were relatively consistent, with self-reported (parent

TABLE 4 Summary of studies examining associations between food retail environments, diet and obesity

Author	Study Design	State/Geographic Area	Sample, n	Diet/Obesity Measure	Food Environment Variable	Food Environment Measure	Associations	Key Findings
Association between food retail environments and diet-related outcomes								
Baldock 2018[70]	Longitudinal	Adelaide, South Australia (metropolitan)	1,491	Fruit and vegetables	Fruit and vegetable retailers = Supermarkets and greengrocers	Proximity: from residence.	Non-significant	Objectively measured distances to fruit and vegetable retailers was not associated with fruit and vegetable intake (*P*=.26).
Moayyed 2017[77]	Cross-sectional	Illawarra, New South Wales (10 suburbs)	230	Fruit and vegetables, discretionary foods, sugar sweetened beverages, milk type, and water.	All food outlets.	Food environment score; Relative Food Environment Index	Significant: as hypothesized	Healthier food environments were associated with healthier diets, whereas unhealthier food environments were associated with unhealthier food intakes (*P*=.01-.05).
Murphy 2017[59]	Cross-sectional	Melbourne, Victoria	3128	Fruit and vegetables	Supermarkets (branded) and chain fast food (top 6)	Proximity: from residence. Density: 800m, 1,000m, 1,600m, 3,000m from residence.	Non-significant	Across most access measures (density and proximity) to supermarkets and fast food outlets there was no association with fruit and vegetable intake. Effect size of significant associations was too small to be of practical significance.
Pereira 2010[78]	Case Study	National (Resettled refuges)	10	24-h dietary recall.	All food outlets.	Proximity: from residence. Density: 2km from residence.	Mixed	Participants that lived within 1km of a major chain supermarket consumed significantly more vegetables than those living further (*P*<.05). No other associations reached significance.
Thornton 2010[75]	Cross-sectional	Melbourne, Victoria (45 suburbs)	1399	Fruit and vegetables, fast food	Greengrocers, chain supermarkets and chain fast food	Proximity: from residence. Density: 3km from residence.	Mixed	Women who reported frequent fruit and vegetable consumption had greater availability

(Continues)

TABLE 4 (Continued)

Author	Study Design	State/Geographic Area	Sample, n	Diet/Obesity Measure	Food Environment Variable	Food Environment Measure	Associations	Key Findings
								of fruit and vegetable items within greengrocers. Frequent vegetable consumers lived closer to, and had a higher density of supermarkets and greengrocers ($P<.001$). Women reporting to have never consumed fast food had higher density and variety of fast food near home (<0.05). Food retail environment features did not mediate socio-economic variations in fruit and vegetable consumption.
Thornton 2013[76]	Cross-sectional	Melbourne, Victoria (32 neighbourhoods)	932	Fast food	Greengrocers, chain supermarkets, chain fast food (>100 outlets in Australia)	Proximity: from residence within 0.8, 1.6, or >1.6km. Density: 3km from residence.	Mixed	Women that lived greater than 1.6km from supermarkets were less likely to be infrequent fast food consumers than those living within 0.8km. Other measures of access to supermarkets, fast food outlets and greengrocers were not statistically significant.
Thornton 2015[71]	Cross-sectional	Victoria (urban/rural)	4335	Fruit and vegetables	Chain supermarkets and greengrocers	Density: 0.8, 2 and 3km from residence.	Non-significant	As a moderator, food store access did not significantly modify associations between fruit and vegetable consumption and factors that relate to ability and motivation in a sample of women.

(Continues)

TABLE 4 (Continued)

Author	Study Design	State/Geographic Area	Sample, n	Diet/Obesity Measure	Food Environment Variable	Food Environment Measure	Associations	Key Findings
Thornton 2016[79]	Repeat-cross sectional	Melbourne, Victoria (2 suburbs)	Baseline: 243. 3 months: 227 12 months: 205	Fast food	Fast food (McDonalds); audit "other" food outlets	Audit of food outlets with 3km of McDonald's site.	Non-significant	There was no significant change in the consumption fast food after the introduction of a new McDonalds after 12 months. No significant change in other food retail within 3km of the McDonalds site.
Timperio 2008[74]	Cross-sectional	Greater Melbourne and Geelong (schools): Victoria	Parents: 340 Children: 801	Fruit and vegetables (parent report)	Supermarkets (chain), greengrocers and fast food chains	Proximity: from residence. Density: existence of ≥1 outlet and number of outlets within 800m from residence.	Mixed	Increased density of fast food outlets was associated with children's decreased fruit intake ($P<.05$), as was the number of convenience stores and lower vegetable intake ($P<.05$) compared with those with lower density. More convenience stores within 800m was associated with lower odds of fruit and vegetable intake ($p<0.01$). More fast food outlets were associated with lower odds of fruit intake ($p<0.05$), whereas likelihood of vegetable consumption increased with distance to supermarket and fast food outlets ($p<0.001$).
Timperio 2009[61]	Cross-sectional	Greater Melbourne and Geelong (schools): Victoria	816.	Fruit and vegetables (parent report)	Takeaway and fast food outlets (incl. cafes and restaurant, convenience stores)	Proximity: from residence. Density: existence of ≥1 outlet and number of	Mixed	Access to fast food and takeaway outlets did not predict frequency of consumption in the direction hypothesized.

(Continues)

TABLE 4 (Continued)

Author	Study Design	State/Geographic Area	Sample, n	Diet/Obesity Measure	Food Environment Variable	Food Environment Measure	Associations	Key Findings
						outlets within 800m from residence.		Children having one or more fast food outlets close to home was associated with consuming takeaway and fast food less often than those with none (negative direction; $P<.05$). No other significant associations were found for other measures of food retail.
Trapp 2015[73]	Cross-sectional	Perth, Western Australia (new housing developments)	565	Healthy/unhealthy food	Supermarkets (major/minor)	Proximity: presence supermarket ≥800m, 1.6km, and 3.2km from residence.	Mixed	Healthy eating scores were positively associated with having supermarket within 800m from home ($P<.05$). No other significant associations were found for other measures of food retail.
Williams 2010[72]	Cross-sectional	Melbourne, Victoria (45 suburbs; low socio-economic position)	355	Fruit and vegetables	Supermarkets (chain) and fruit and vegetable stores.	Proximity: from residence. Density: within 2km from residence.	Non-significant	No significant associations between fruit and vegetable consumption and availability of supermarkets and fruit and vegetable retailers.
Association between food retail environments and obesity-related outcomes								
Abbott 2014[60]	Cross-sectional	Melbourne, Victoria (15 suburbs; low, mid and high SEIFA)	1,819 (women)	Self-reported height and weight (BMI)	Major chain supermarkets, greengrocers and fast food	Proximity: from residence. Density: 2-km buffer	Mixed	Living closer to a supermarket, when considered individually, was associated with lower BMI in more educated women only ($P<.05$).
Baldock 2018[70]	Longitudinal	Adelaide, South Australia (metropolitan)	1491	Central obesity measured via trained clinic staff.	Fruit and vegetable retailers = supermarkets and greengrocers (2007)	Proximity: from residence.	Non-significant	Objectively measured access to fruit and vegetable retailers was not associated with any

(Continues)

TABLE 4 (Continued)

Author	Study Design	State/Geographic Area	Sample, n	Diet/Obesity Measure	Food Environment Variable	Food Environment Measure	Associations	Key Findings
								measure of cardio metabolic risk, including a measure of central obesity.
Bussey 2012[88]	Cross-sectional	Fitzroy Valley, Western Australia	401	Waist circumference and BMI	Six community stores	Remote Indigenous stores and takeaway: "how healthy is your store checklist."	Non-significant	Healthy store score was not associated with waist circumference and BMI.
Crawford 2008[87]	Cross-sectional	Melbourne, Victoria (schools)	702	Children measured height and weight (BMI); Adult self-report height and weight (BMI)	Fast food (8 chains)	Proximity: from residence. Density: 2-km buffer.	Significant: opposite to hypothesized direction	Children with at least one fast food outlet within 2km of home had a lower BMI as did adult males ($P<.05$). Parental (father) BMI increased the further they lived from a fast food outlet.
De Vogli 2011[86]	Ecological	Australia	National	BMI (World Health Statistics; WHO 2009)	Subway Restaurants	Density: per 100,000 people country.	Significant: as hypothesized	Australia was one of 26 countries with advanced economies included in this analysis. There was a positive association with the density of Subway restaurants and the prevalence of obesity in both genders (male $P=.02$; female $P=.01$) for adults (>15 years).
Feng 2018[81]	Longitudinal (Participant only)	Sydney, New South Wales (metropolitan)	15,229	Self-reported height and weight (BMI)	Healthy (supermarkets and greengrocers) and Unhealthy (fast food chain and independent)	Density: 0.4, 0.8, 1.6, and 3.2km from residence. Ratio: healthy to unhealthy.	Mixed	There were no associations at 0.4 or 0.8km, however, higher mean BMI (adults aged 45 and over) was associated with having food retail environments comprising greater than 25% of fast food outlets within 1.6km and 3.2km from home

(Continues)

TABLE 4 (Continued)

Author	Study Design	State/Geographic Area	Sample, n	Diet/Obesity Measure	Food Environment Variable	Food Environment Measure	Associations	Key Findings
								compared to no outlets (P<.05).
Lamb 2017[84]	Longitudinal	Victoria (rural/urban)	882	Self-reported height and weight (BMI)	Fast food (10 major chain)	Density: 2, 3, and 5km from residence.	Non-significant	There was no evidence to suggest that change in BMI was associated with residential availability of fast food in women (aged 18-46 years).
Miller 2014[82]	Cross-sectional	Perth, Western Australia (metropolitan)	1850	Parent reported child height and weight (BMI)	Healthy (supermarkets, general stores, fruit and vegetable retailers, butchers), unhealthy (fast food chain and independent.	Proximity: from residence. Density: 800m and 3-km buffer. Ratio: healthy to unhealthy.	Mixed	Children with a healthy food outlet within 800m from home was consistently associated with decreased risk of overweight and obesity (P<.05)
Murphy 2017[59]	Cross-sectional	Melbourne, Victoria (12 Local Government Areas)	1491	Self-reported height and weight (BMI)	Supermarkets (chain) and fast food (chain top 6)	Proximity from residence; Buffers around home residence: Pedestrian Road Network: 800m, 1,000m, 1,600m Road Network: 2,000m, 3,000m	Mixed	Supermarket density was protective of BMI for participants in high disadvantaged areas only at 800m (P=.040) and 1,000m (P=.032). No significant associations were found at buffers greater than 1.6km.
Murphy 2018[69]	Mixed methods	Melbourne, Victoria (6 established and 6 urban growth areas Local Government Areas)	3141	Self-reported height and weight (BMI)	Supermarkets (chain) and fast food (chains top 6)	Proximity from residence; Buffers around home residence: Pedestrian Road Network: 800, 1,000, and 1,600m Road Network: 2,000m, 3,000m	Mixed	Significant associations between BMI and both supermarket and fast food were found at 3,000m, however the effect size was considered too small (-0.08km/m^2) to be of significance. For all other measures there was no evidence to suggest supermarket access (proximity or density) was associated

(Continues)

TABLE 4 (Continued)

Author	Study Design	State/Geographic Area	Sample, n	Diet/Obesity Measure	Food Environment Variable	Food Environment Measure	Associations	Key Findings
								with BMI. Higher fast food density was associated with higher BMI at 800m (p=0.047) and 1000m (p<0.001) buffers for participants in established areas. In contrast, for participants in urban-growth areas increasing fast food density was associated with lower BMI within 800m (p=0.043) and 1600m ((p=0.002) buffers. Fast food proximity to home in association with BMI was non-significant.
Paquet 2014[83]	Longitudinal ?>? >(Participants only)	Adelaide, South Australia (metropolitan)	3205	Central obesity measured via trained clinic staff.	Healthy (supermarkets, greengrocers and butchers), more healthful takeaway options (eg, sushi), unhealthy (fast food, bakers and sweet food shops)	Ratio: healthy to unhealthy	Significant: as hypothesized	The healthiness of the food retail environment was associated with abdominal obesity, with unhealthier food environments associated with increased incidence of abdominal obesity (*P*=.028)
Simmons 2005[85]	Cross-sectional	Victoria (regional)	1454	Waist circumference; Height and weight measured in clinic (BMI)	Takeaway and sit in restaurants.	Density: Number of eating placed per 1,000 population for each town.	Non-significant	There was no association with the number of eating placed and BMI or waist circumference.
Tseng 2014[80]	Longitudinal	Victoria (urban/rural suburbs)	3786	Self-reported height and weight (BMI)	Chain supermarkets and fast food and greengrocers.	Density: 2-km buffer around residence. Sensitivity analysis 0.8 and 3km.	Non-significant	There was no association between the food environment domain and BMI in this sample of women. (adjusted by age, country of birth, education and illness at baseline)

Abbreviations: BMI: body mass index; SEIFA: Socioeconomic Index for Areas.

reported where a child participated) dietary consumption of fruit and vegetables,[59,61,70-72,74] fast food,[76,79] or both healthy and unhealthy foods[73,75,77,78] measured using/adapting validated tools in most studies.

One study across 10 suburbs in the Illawarra region of New South Wales reported significant associations in the direction hypothesized.[77] Suburbs scoring higher (higher being healthier) using a food retail environment healthiness rating system developed by Moayyed et al[101] were associated with higher consumption of fruit and vegetables[77]. The same study reported a significant positive correlation between healthiness of the food retail environment, measured using the Relative Food Environment Index, and four diet scores (total diet, fruit and vegetable, sugary drink and discretionary food—higher being healthier for all scores).[77] Five studies reported non-significant associations between fruit and vegetable intake and proximity to and/or density of supermarkets and/or greengrocers/fruit and vegetable retailers,[70-72] chain supermarkets and fast food outlets[59] or the introduction of a new fast food outlet on fast food consumption.[79]

Six studies reported mixed results,[61,73-76,78] where alongside non-significant associations, many significant associations were reported. Healthy eating scores[73] and fruit and vegetable consumption was higher for women[75] and newly arrived refugees,[78] and fast food consumption was infrequent[76] when supermarkets were more proximal and of greater density near home. In contrast, women with greater density and variety of fast food near home were significantly more likely to report never consuming fast foods[75]; but for children, this was associated with greater consumption of fast food[61] and decreased fruit intake. For those with a greater density of convenience stores, lower fruit and vegetable intakes were reported.[74]

3.4.2 | Australian food retail environments and obesity

Thirteen studies examined associations between food retail environments and prevalence of people with obesity (Table 4). Outcome measures for prevalence of people with obesity were most often collected through self-report (or parent-reported) height and weight to generate BMI ,[59,60,69,80-82,84] four studies objectively measured central obesity/waist circumference[70,83] two of which used BMI as a measure also.[85,88] One study used adult/parent self-reported BMI with children's BMI objectively measured,[87] and one study[86] used the World Health Statistics from 2009 to estimate national prevalence of people with obesity.

Methods used in this group of studies were heterogeneous, with no two studies measuring the same food retail environment characteristic. Five studies found no significant association(s).[70,80,84,85,88] Two studies found significant associations in the hypothesized direction, whereby healthier food retail environments were associated with lower measures of people with obesity).[83,86] DeVogli et al[86] found a higher density of Subway restaurants (considered by the study authors as an unhealthy fast food outlet) in Australia was positively associated with adults who have obesity, and Paquet et al[83] found the incidence of abdominal obesity increased as the ratio of unhealthy food retail outlets increased relative to healthy outlets. In contrast, Crawford et al[87] found that children and adult males with at least one fast food outlet within 2km of home had a lower BMI than those that did not, and parental (father) BMI increased the further they lived from a fast food outlet.

Five studies reported mixed results.[59,60,69,81,82] Using a relative measure of healthy to unhealthy food outlets, Feng et al[81] found that having fast food outlets (considered by the authors as "unhealthy") comprising greater than 25% of food outlets (relative to healthy food outlets) within 1.6 and 3.2km (but not at 0.4 or 0.8km) of home was positively associated with BMI. Miller et al[82] found that children with a healthy food outlet (supermarkets, general stores, fruit and vegetable retail and butchers) within 800m of home (but not at 3km) were consistently associated with decreased risk of people with overweight and obesity. Abbott et al[60] found that living closer to a supermarket was associated with lower BMI, but this was the case for more educated women only. In contrast, Murphy et al[59] found that density of supermarkets within 800m was protective (negatively associated) with respect to BMI but only in more disadvantaged areas. In a second study, Murphy et al[69] found no evidence to suggest supermarket access or fast food proximity to home residence was associated with BMI across established and urban-growth local government areas. In this study, higher density to fast food in established local government areas was associated with a higher BMI, whilst in urban-growth areas, higher fast food density was associated with lower BMI.[69]

4 | DISCUSSION

This review examined food retail environments in Australia, describing published peer reviewed studies that have measured the healthiness of food retail environments, the way they vary by geographic area and SEP, and associations between the healthiness of food retail environments and diet and/or people with obesity. The broad range of methodological approaches considered in studies included in this systematic review reflects the complexity of food retail environments in Australia, and the infancy of research in this space. Consistent with previous systematic reviews on food retail environments in the United States and Canada, methodological heterogeneity made synthesis of results difficult and limited the ability to draw conclusions.[30,35] Overall there was inconsistent evidence regarding the association between the healthiness of food retail environments, diet and people with obesity. However, there is some evidence that disparities exist in food environments across measure/s of SEP and geographic areas in parts of Australia, with healthier food retail environments reported more often in inner urban areas and areas of more advantage in Victoria.

Most (41 out of 60) of the studies included in this review had cross-sectional study designs. Five longitudinal studies were included, two of which measured health outcomes over time against only one baseline measure of environmental attributes.[81,83] The remaining three longitudinal studies provide minimal reporting on the changing characteristics of the food retail environment over time.[70,80,84] Future

longitudinal studies could be valuable in establishing the direction of causality in associations between food retail environments and health-related outcomes over time.[32,102,103] Two ecological studies were included in this review, both of which reported significant associations in the hypothesized direction[55,86]. The potential for both spatial autocorrelation (ie, where characteristics of the built environment in nearby areas are likely to be similar/correlated, and built environments further away are likely to be more diverse) and the likely large similarities between geographically separate food environments in the same country need to be taken into account when designing future studies.[35] To understand the true relationship between exposure and outcomes, more ecological studies are needed comparing larger and contrasting geographic areas having very different food retail environments, alongside population level data.[35] These studies may also need to include measures of the food environment beyond just the food retail environment such as food composition, food labelling and food prices.

Caspi et al[29] further supports this view, emphasizing the need for greater understanding of the utilization of food retail environments by people and populations (ie, where, when and how people purchase their food). Future food retail environment measures need to represent the catchment area, or influential area of each food outlet on the population, which are often expressed as the distance people are likely to travel to shop.[26,55]

In a methodological review of Geographic Information Systems (GIS) measures of the food environment by Charreire et al,[102] it was found that circular buffer techniques ranging between 100m and 2.5km were the most frequently used spatial measure of the food retail environment. In the current review, there was a predominant focus on environments near an individuals' residence with buffers ranging from 400m to 3km (although two studies used 3.2km and 5km buffers). This may represent a nuance of the expansive Australian food retail environment. Recent Australian evidence suggests that, on average, individuals purchase food a median distance of 3.6km from the home, with the majority of purchases occurring less than 20km from home.[104] These data suggest that future research should examine larger geographic units because examining small areas (2-3km) around an individual address alone appears to be inadequate.

Four of the studies included in this review used a relative measure of the food environment, examining the ratio of healthy food outlets relative to unhealthy food outlets in association with people who have obesity[81-83] and diet.[77] Consistently, lower BMI in children[82] and adults,[81,83] as well as healthier diet in adults,[77] was associated with higher proportions of healthy food outlets. This indicates that it may be the ratio of healthy food stores to unhealthy food stores that is important in understanding the association between food retail environments and health-related outcomes, and that getting the appropriate retail balance may be key to prevention efforts. Moreover, in developing standardized and validated measures of the healthiness of food retail environments, a comprehensive approach should be taken, endeavouring to incorporate multiple measures of the food environment. For in-store studies, it would be useful to have a standardized tool to measure the healthiness of various food outlet types similar to the healthy food basket tool used in supermarket assessments. For food outlet types, it may include an index of common Australian food outlet types alongside a healthiness rating allowing for the classification, collation and evaluation of the healthiness of all food outlet types available within areas. In this regard, it would be valuable to further test the reliability and validity of tools such as the Food Environment Score[77,105] that gives food outlets a healthiness rating, which can be used to calculate a Food Environment Score (higher being healthier) for an area.

The difficulty we had in drawing conclusions from this review are resultant of methodological heterogeneity and is consistent with the limitations reported in previous systematic reviews on food retail environments in the United States and Canada.[30,35] Despite this difficulty, this study and both of the previous reviews indicate that there is some evidence the food retail environments within the United States, Australia and Canada differ by measure/s of SEP. However, the variation is not uniform. Where in the United States, food deserts are evident in areas of disadvantage; in Canada, the access to grocery stores and supermarkets is the same if not better in deprived areas, with disparities existing in only the abundance of EDNP food being higher in more disadvantaged areas.[35] In New Zealand, a recent report from INFORMAS identified a similar trend in variation by measures of SEP with areas of disadvantage more likely (14%) to be considered a food swamp, with higher overall retail food availability and 33% more unhealthy food outlets around schools in urban areas.[34]

4.1 | Strengths and weaknesses of the review

This is the first systematic review of the Australian food retail environment and contributes to the growing international literature examining country-level food retail environments. A strength of this study is the inclusion of all published peer reviewed studies regardless of whether a statistical analysis was undertaken, allowing for the compilation of descriptive statistics and inclusion of case studies and geographic analyses from rural and remote communities that would have otherwise been excluded. Future reviews may benefit from examining the more distal measure of food purchasing in association with the food retail environment and the inclusion of grey literature on the Australian food retail environment, which was not examined in this review. Additionally, the development of a standardized quality assessment tool for papers examining food retail environments would greatly benefit future systematic reviews on the topic.

While heterogeneity across studies aims and methodology limits the ability to draw strong conclusions across studies, important areas for future research have emerged. Whilst in-store food availability can be measured using a validated healthy food basket tool, at the spatial level, a reliable tool for measuring the food retail environment is lacking.[45] Across the studies included in this review, there were an extensive number of different measures used, with more than 15 measures of food retail access across 12 different combinations of food outlet types. This heterogeneity is the result of the absence of

standardized and validated tools to measure access and composition of the food retail environment as there is no agreed definition of what is "good access" to healthy food. For example, good access to healthy food was defined in one study as 10-min driving distance to a supermarket,[54] whereas, in another study, good access was considered 500m from home and justified as the maximum distance for carrying shopping on foot.[53]

4.2 | Implications for practice

Whilst on a national level evidence is inconsistent for Australia, in the state of Victoria, evidence suggests that disparities exist in the food retail environment across both geographic areas and SEP measures.[41,47,59,65,68,69] This evidence emphasizes the need for further research to support urban planning, policy and practice for healthier food environments, particularly in areas of disadvantage.[59] Food retail environment literature implies disparities in the food environment could be due to factors such as residential self-selection (which suggests people choose to live in areas based on criteria that relate to both food environments and health-related outcomes such as obesity),[106] consumer-driven demand (which is based on the premise that populations of lower SEP measures have a preference for unhealthy food and vice versa), reverse causation (where purchasing behaviour may be the driving factor behind greater numbers of food outlets)[32,107] or market-driven demand (whereby food businesses make commercial decisions to target particular areas).[32] Whilst disparities in the food retail environment could be a result of a combination of the above factors, we are limited in our understanding due to a lack of longitudinal studies examining the food retail environment that could provide evidence demonstrating how food retail environments are established and expanded over time.[108] Growing use of GIS to assess geographic distribution of food outlets could assist in understanding the longitudinal changes in spatial distribution of food outlets and the causal links between food retail environments and health-related outcomes over time.[32,102,103]

The development of an interactive mapping and monitoring tool for the food retail environment using reliable and accurate datasets would provide a valuable public health resource for researchers, urban policy makers and planners. Within the literature, information on the types of food retail outlets in a particular area has strongly relied on commercial datasets, which are limited because participation in the list is voluntary and food retailers can opt to not be listed in these datasets. The development of a monitoring tool for the Australian food retail environment would benefit from the sourcing of more reliable data. Sourcing of food retail environment data via field validation is considered the most accurate in the realm of food retail environment research; however, the use of this method in a large geographic area is not feasible.[109] Second to field validation, the register of food premises held by each local government Environmental Health Unit is found to accurately and comprehensively indicate the food outlets present at a given point in time and be more accurate than commercially sourced datasets.[109,110] Local government food retail data have the potential to be routinely geocoded and incorporated in an interactive food retail environment data source for future research and use by urban policy makers and planners.

The key findings from this review are likely to be highly relevant to other countries, particularly Western countries with food supplies broadly similar to the Australian context. Few studies internationally have utilized methods that examine the relative mix of healthy and unhealthy food retail outlets; however, the consistency of their findings suggests that it may be the ratio of healthy food stores to unhealthy food stores that is most important in influencing food purchasing and consumption behaviours, and getting this balance right may be key to prevention efforts.[26,111] This method for examining food retail environments is likely to be applicable in a broad range of countries. The findings from this review also provide support for the establishment of reliable routine monitoring of food retail environments in all countries, as recommended by INFORMAS to occur annually or at most once every five years.[112]

5 | CONCLUSION

The crucial role of food environments, and the need to address the healthfulness of food environments, is highlighted across all global and national reports on diet and obesity prevention. Our findings indicate that inequities exist in the food retail environment within Australia, with communities living in areas of lower SEP and further from metropolitan centres exposed to unhealthier food retail environments. Current methods used to measure the food environments in Australia are limited and inadequate and need to be improved in order to better assess how changes in food environments impact health and to evaluate the impact of policy change. Our findings contribute to the growing international evidence-base benchmarking country-specific food retail environments globally and support the call for standardized and validated measures, as well as routine monitoring of the food retail environment to improve equity in food retail environments, and improvements in diet-related health outcomes.

CONFLICT OF INTEREST

No conflicts of interest declared.

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of the article.

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