

FedUni ResearchOnline

<https://researchonline.federation.edu.au>

Copyright Notice

This is the post-peer-review, pre-copyedit version of an article published in Food Security. The final authenticated version is available online at:

<https://doi.org/10.1007/s12571-015-0491-4>

Copyright 2020 Springer Nature Switzerland AG.

Quantifying and visualizing access to healthy food in a rural area of Australia: a spatial analysis

Abstract

A Geographical Information System (GIS) using ArcGIS tools was adopted to implement three types of spatial analysis: coverage, density and proximity, to evaluate the geographical access to healthy food of the populations in Dorset Municipality, Tasmania, Australia. Data on food outlets the aggregated socioeconomic disadvantage index, locations, income and population were collected using the Tasmanian Food Outlet Audit and Tasmanian Healthy Food Basket tools spatial autocorrelation was conducted where appropriate to examine the relationship between locations and food access. Healthy food outlets were concentrated in the central areas, areas in proximity to the national road and areas of dense population. Their locations also, favored the more socio-economically deprived or disadvantaged areas (Moran's Index=0.924, z-score=5.187, p-value=0.00 < 0.05). Spatial identification of food deserts in Dorset has been a pioneering attempt to visualize areas with the highest demand for improvement in healthy food access and may be applicable to other areas with similar characteristics.

Keywords: food security, food access, food deserts, healthy food, proximity, spatial analysis

Introduction

Geographic access to food

A body of recent research surrounding food security has been devoted to the investigation of geographic access to healthy food resources (Clarke et al., 2002; Clifton, 2004; Moreland et al., 2002; Sharkey & Horel, 2008). Food security was first recognized as a global issue in 1996 when it was defined as a situation that “exists when all people, at all times, have physical, social and economic access to sufficient safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life” (FAO, 1996). In the Australian context, it is referred to as “the ability of individuals, households and communities to acquire food that is sufficient, reliable, nutritious, safe, acceptable and sustainable.” (Rychetnik et al., 2003)

As a determinant of food security, geographic access examines the contribution of the geographic environment to healthy food choices and consumption. It normally deals with the type, spatial distribution, density and proximity of food outlets in a neighborhood. For example, the availability of supermarkets and full service restaurants is reported to be associated positively with the consumption of healthy foods, which includes fruits and vegetable (Adu-Nyako, 2011). Similarly, the quantity and types of retail stores were found to influence the food consumed by the community (Bodor et al., 2008). In a study of intervention in retail provision Wrigley et al. (2003) found a positive, albeit modest, impact on the diet of a previously poor-retail-access community in Britain between 2001 and 2002. These positive associations indicate that improving geographic access to healthy food may lead to its increased purchase and consumption. .

Geographic access to food and socio-economic disadvantage

Poor geographic access to healthy food outlets has been documented as a characteristic of more deprived neighborhoods, such as those in rural and remote areas. Sharkey and Horel (2008) found in rural Texas, USA that 20% of all rural residents were at least 17.7 km from the nearest supermarket or full-line grocery store and 7.6 km from the nearest convenience store, where a full range of healthy foods were accessible. Similarly, McCluskey (2009) reported that few residents in Moreland, Victoria, Australia were within 400m of a fresh fruit and vegetable outlet.

Lack of public transport and ownership of cars makes shopping for food a challenge in rural areas (Sharkey & Horel, 2008).

Examining access to food among advantaged and disadvantaged areas in outer Melbourne, Burns and Inglis found that the former had closer access to supermarkets, which offered a diverse range of healthy foods, while the latter had closer access to fast food outlets (Burns & Inglis, 2007). Ball, Timperio and Crawford (2009) came to the same conclusion i.e. that geographical access to healthy food stores in Melbourne was better in more advantaged neighborhoods. Similarly, Moreland et al. (2002), found in Mississippi, North Carolina, Maryland, and Minnesota, USA, that more supermarkets were located in non-poor neighborhoods than poor neighborhoods. This spatial inequality in favor of the more advantaged areas has been noted by many other researchers in the field (Jensen et al., 2003; Powell et al., 2007), although some reported the opposite (Cummins & Macintyre, 2002; Macintyre, 2007; Pearce et al., 2007; Sharkey & Horel, 2008).

Limited geographic access to food seems to be an exclusive concern of economically deprived populations because it presents more than just a spatial challenge. Residing in areas of impoverished food resources, low-income populations struggle not so much with the geographical barrier as the financial challenge associated with it. They either have to pay higher transport costs in order to visit larger food outlets or shop at smaller food stores at higher prices and with more limited choice (Sharkey & Horel, 2008). The Healthy Food Access Basket survey in Queensland, for example, showed that the overall cost of food was significantly higher in remote and rural areas, hovering around 30% greater, than in major cities (Queensland Health Treasury, 2000, 2006). Similarly, Food Supply in Rural South Australia reported higher prices and fewer varieties of foods for people living in small regional centers (Meedeniya et al., 2000).

In Western Australia, the Food Access and Costs Survey indicated that food prices and food access were closely related to geographic location, and favored socio-economically advantaged areas. Importantly, healthier foods such as fruit, vegetables and dairy were 32%, 26% and 40% higher in price, respectively, in remote areas (DOH (WA), 2010). In the Northern Territory, the 2008 Market Basket revealed that the food cost in remote stores was 23% more expensive than in a Darwin supermarket, and 19% more expensive than in a Darwin corner store (Northern Territory Government, 2008). The clearly-manifested link between the spatial dimension with other aspects of food access, especially financial access, shows that the poorer populations bear the brunt of limited geographic access to healthy food resources (Rose, 2010).

Interests in the relationship between geographic food access and neighborhood disadvantage have given rise to the emergence of the term “food desert”, which is defined as a relatively excluded area, where people are faced with physical and economic barriers to healthy food (Cummins & Macintyre, 2002; Guy & David, 2004; McEntee & Agyeman, 2010; Wrigley, et al., 2003). Low-income populations in areas with non-existent or poor food retail provision live in such food deserts and they are the most vulnerable to food deprivation. For this reason, research efforts to identify food deserts have often targeted socio-economically disadvantaged areas. These studies share the same primary objective of quantifying the existence and severity of food deserts. In many key studies, an important indicator of inadequate retail food provision is the limited availability and accessibility of supermarkets, where a wide range of healthy foods are accessible within neighborhoods (Apparicio et al., 2007; Besharov et al., 2011; Lee & Lim, 2009; Schafft et al., 2009).

Although many studies have been conducted internationally and nationally on geographic access to healthy food, there is a complete absence of evidence concerning this issue in the regional and rural areas of Australia. Within this context, the study was conducted with a view to building a more evidence-based understanding about this spatial and environmental aspect of healthy food access in Tasmania, Australia. Whilst there have been efforts made to address the causes of food insecurity in Tasmania through measures such as the implementation of the *Tasmanian Food and Nutrition Policy* in 2004 and the establishment of the Tasmanian Food Security Council in 2010, there are limited data on the levels of food security in Tasmania. Part of the Tasmanian Food Security Council’s role was to include the development of a Food Security Strategy for Tasmania and oversee food security activities in the state.

Within a wider food security research activity, Dorset was chosen as a rural and remote region in which to develop and trial a number of food securities models (Le et al., 2013).

In addition to these wider goals, this study aimed to quantify and visualize geographic access to healthy food in Dorset, compare areas of different socio-economic disadvantage there in terms of geographic access to healthy food and determine the existence or non-existence of food deserts in the study area.

Methods

Study site

The municipality of Dorset was chosen as the research site for this study. Dorset has a population of 6,834 people spread over 14 districts and includes 40 townships and population centers (ABS, 2011b, 2012b) It covers 3,227 km² with a population density of 2.1 people per square kilometer and does not have a functioning public transport system. Dorset has experienced a population decline of 5.2% in the period 2001 – 2011 (ABS, 2011b, 2012b) and those remaining are ageing. Accessing services can be difficult as 96% of Dorset's population is classified as living in Outer Regional Australia and 4% is classified as living in Remote Australia (AIHW, 2011). Outer regional and remote are defined as areas in Australia where geographic distance causes moderate or high "restriction upon accessibility to the widest range of goods, services and opportunities for social interaction." (ABS, 2011a)

In addition, Dorset has a high level of socio-economic disadvantage when compared to other regional areas and state levels, particularly in education and occupation, two of the most powerful determinants of health. Nine out of 14 districts in Dorset have a SEIFA "Index of Relative Social Disadvantage" (IRSD) (ABS, 2013a) within deciles 1 and 2, i.e., within the 20% of the most disadvantaged areas in Australia. Currently, 39.3% of the Dorset population are living in the lowest decile of socio-economic disadvantage with only 48.8% of the working age population being employed (ABS, 2013b).

Data for local food outlets

There were different data sources for the quantification and visualization of geographic food access in Dorset. The primary source of data was collected using the Tasmanian Food Outlet Audit Tool (Le, et al., 2013). Initially, shop owners were informed of the study and the food outlet auditing process. Research assistants then visited each food outlet that was listed on the Dorset Council's list of registered food outlets. Using a recent street map, the research assistants reconciled the list provided with current maps, adding any food outlets that were missing from the original list. Whilst visiting each food outlet, the research assistants recorded the relevant data concerning the food outlet category and the range of food available. The local food outlets were categorized into the following types: alcohol outlets, bakery and cake shop, butcher store (includes poultry), café/coffee shop, fruit and vegetable shops, markets, mobile fruit and vegetable van, local farm gate sales, local/corner store, major supermarket, minor supermarket (grocer), pub/hotel/club dining areas, restaurant/cafes with sit down service, and takeaway food outlet.

For the purpose of this study, the 15 categories of food outlets were further classified into healthy and non-healthy ones. To achieve this, the Tasmanian Healthy Food Basket (THFB) was used to guide their classification (Le, et al., 2013). The 'Healthy Food Basket' is a list of food items chosen to represent commonly available and popular food choices, which provide enough food to meet the nutritional needs of four different family types for a fortnight. Items that are included in an HFB include Bread and cereals, Fruit Vegetables, Legumes, Dairy, Meat and alternatives and Non-core foods such as oil and sugar. HFB surveys have been widely used in Australia as a measure of the cost of eating well and is based on the Australian Guide to Healthy Eating (AGHE) (Department of Health, 2014).

To classify the food outlets within Dorset, those that were stocking 90% (9 – 10 items) of the healthy food basket were considered to be healthy food outlets. The components of these include fresh fruit, fresh vegetables, meat

(including fish and chicken) bread, pasta, cereals (including rice, grains), breakfast cereal, eggs, milk, and yoghurt or cheese. It is worth noting that a special emphasis was placed on fruit and vegetables because they are essential for a healthy and nutritious diet. Through the audit process, nine healthy food outlets were identified (out of a total of 48 in Dorset), including major and minor supermarkets, fruit and vegetable shops, mobile fruit and vegetable vans, and local/corner stores.

Due to their seasonal and very limited operations, farmers' markets and community gardens were not included in this study. Only one registered seasonal farm gate was operating within the municipality, 14km east of Scottsdale (Fruit Growers Tasmania, 2012) and at the time of the audit there were no farmers' markets in Dorset registered with the Australia's Farmers' Markets association (Australia's Farmers' Markets association, 2013; Eat Well Tasmania, 2013). Despite this, individuals within the main town, Scottsdale,, were assessing the viability and development of farmers' markets and seeking municipal approval for establishing them every two to four weeks (Le, et al., 2013). While there was a number of non-registered farm gate or roadside stall sales, these were excluded from the study as they provided very limited or seasonal food items which could not be considered reliable or which did not provide a regular source of food for the community (such as local petrol stations which may sell a single line of potato). Roadside or residential sales of homegrown produce were also excluded. Although regularly used by some local residents, the non-regulated, sporadic and seasonal nature of these operations were considered to be unstable sources of food for the community and would be difficult to track for the purposes of this study (Le, et al., 2013).

The primary purpose of the data collected from this outlet audit process was to produce maps for the location, distribution, and density of local food outlets. The secondary sources of data included the SEIFA Index (ABS, 2013a), digital boundaries (ABS, 2011c), Mesh Block (ABS, 2011a), income and population information (ABS, 2013c), township or district locations (GeoScience Australia, 2012), address-point layers, and transport layers (DPIPWE, n.d.). These secondary sources of data were used for the display of the district boundaries, road network and population density, the geocoding of actual food outlets' addresses, and the analysis of socio-economic status of townships or population centers in Dorset.

Measures of geographic food access

Many methods have been used to examine the geographic dimension of food access. Among them, mapping access to food stores using the GIS tool has been proven to be a useful and effective approach (Block et al., 2004; McEntee & Agyeman, 2010; Raja et al., 2008; Sparks et al., 2009). It facilitates spatial analysis and allows for the identification of areas of low food access. In this study, GIS mapping was used in conjunction with three types of analyses in examining the food environment of Dorset.

- *Coverage*: The coverage indicator was used to identify the location and distribution characteristics of the local food outlets in the target municipality. For example, it helped to determine patterns of food access by population density or to identify any inequalities in food exposure and food provision.
- *Density*: A density indicator was used to evaluate access by computing the number of healthy food outlets per population. A density of one supermarket per 1,000 people has been established by previous researchers as adequate access (Hattori et al., 2013; Lee, 2012; Macdonald et al., 2007). We adopted this threshold as an indicator of whether the districts, townships or population centers in Dorset were well-served or under-served by food retail providers.
- *Proximity*: The proximity indicator was used to examine the travel distance to the nearest healthy food outlet of different households based on the current road network. It identified populations that were living within zones of 400m, 1km, or 16km along the road to the nearest healthy food outlets. These spatial measures have been used consistently with the current literature on food access assessment for non-motorized and motorized populations (Apparicio, et al., 2007; Larsen & Gilliland, 2008; McCluskey, 2009; Sparks, et al., 2009). Specifically, walkability was used to measure food access of non-motorized populations. They were said to have easy access to healthy food outlets if they lived within 400m and limited access if they lived

more than 1km along the road (or 0.62 mile as suggested by Sparks et al(2009)). However, many of the rural populations lived further than convenient walking distance from food outlets and more often relied on motorized vehicles for food shopping than their urban counterparts. Therefore, motorized populations were addressed in this study and they were considered to have limited access if they lived outside the 16km radius (or 10 miles as suggested by Morton and Blanchard (2007)) of the nearest healthy food outlet.

- *Spatial autocorrelation (Moran's Index)* was used to explore the association between locations, population density and distribution of healthy food outlets. Any significant findings were noted where the p-value ≤ 0.05 .

Results

The variety of food outlets

The variety of food outlets in local areas is a measure of the quality of the food environment in any community. Dorset had 14 of the 15 different categories of food outlets available across the municipality. These ranged from supermarkets through to local or corner stores. In Dorset, only two population centres, Bridport and Scottsdale had more than five food outlets of any type.

However, the diversity of food outlets does not predict people's capacity to purchase the range of foods required for a household's nutritional and energy requirements. Those food outlets which were designated healthy, stocking 90% of the requirements of a healthy food basket, fell into only four audit categories: fruit and vegetable shops, local or corner stores, major or minor supermarkets. Some of these healthy food outlets were available in areas beyond the centres of food outlet density.

Cost of healthy food at food outlets

The overall and individual food group costs associated with the THFB for each typical household type were calculated in order to indicate the amount of money a household may actually spend at different food outlets as shown in Table 1 (Le, et al., 2013).. In addition, Table 2 (Le, et al., 2013) indicates the cost of food between categories across all household types and shows that the three components of fresh fruit and vegetables, meat and meat alternatives, and dairy each comprised at least 25% of the total price of the THFB.

Table 1: Median cost of a THFB per 2 weeks for four household types by food outlet category

Food Outlet Categories	Two Parent Family (44-year-old male, 44-year-old female, 18-year-old child, 8-year-old child)	Single Parent Family (44-year-old female, 18-year-old child, 8-year-old child)	Older person (>71 years old)	Single Adult (Male >31 years)
Major supermarket	\$493.29	\$334.68	\$116.65	\$153.45
Minor supermarket	\$545.24	\$367.26	\$130.41	\$169.17
Local or corner store	\$514.95	\$337.53	\$121.66	\$163.10
Local or corner	NA	NA	NA	NA

Table 2: Median cost, percentage of total cost and range of the food group components of the THFB per 2 weeks

	Two Parent Family (44-year-old male, 44-year-old female, 18- year-old child, 8-year-old child)	Single Parent Family (44-year-old female, 18-year-old child, 8-year-old child)	Older person (>71 years old)	Single Adult (Male >31 years)
Fresh fruit and vegetable component	\$125.98 (25.0%) (\$101.20-\$140.72)	\$86.79 (25.4%) (\$68.67-\$97.83)	\$31.64 (26.2%) (\$24.84-\$36.22)	\$38.15 (24.3 %) (\$32.77-\$43.10)
Bread and cereal	\$67.43 (13.4%) \$57.08-\$89.65)	\$36.98 (10.8%) (33.37-\$45.68)	\$14.83(12.3%) (\$12.59-\$18.91)	\$25.26 (16.1%) (\$20.83-\$31.61)
Meat and meat alternatives	\$124.5 (24.7%) (\$103.49-\$147.08)	\$81.83 (24.0%) (\$69.22-\$94.84)	\$30.73 (35.4%) (\$25.73-\$36.55)	\$41.18 (26.2%) (\$32.89-\$50.73)
Dairy	\$134.75 (26.7%) (\$100.05-\$154.43)	\$101.21 (29.6%) (\$74.59-\$116.61)	\$30.81 (25.5%) (\$23.13-\$35.22)	\$33.43 (21.3%) (\$25.33-\$37.67)
Non-core food items	\$6.74 (1.3%) (\$5.30-\$12.91)	\$4.36 (1.3%) (\$3.50-\$8.95)	\$1.69 (1.4%) (\$1.36-\$3.49)	\$2.35 (1.5%) (\$1.84-\$4.46)

Cost of food relative to income in Dorset

In addition to calculating cost, the cost of items within the THFB was compared to an estimate of the income support payments received by household type. This income was calculated using Australian Government social security (Centrelink) payment data and ABS Average Weekly Earnings information (ABS, 2012a), as outlined in Table 3 (Le, et al., 2013). Overall, in order to purchase a basket of healthy food that would meet 85% of the nutrients and 95% of the energy requirements of family members, a two parent family with two children whose income source is support payments would need to spend a median 43% of their total income, whereas a two parent family of four on average wages would need to spend 22% of their income to purchase the same food items.

Table 3: THFB Household types, income and percentage of income required to purchase THFB

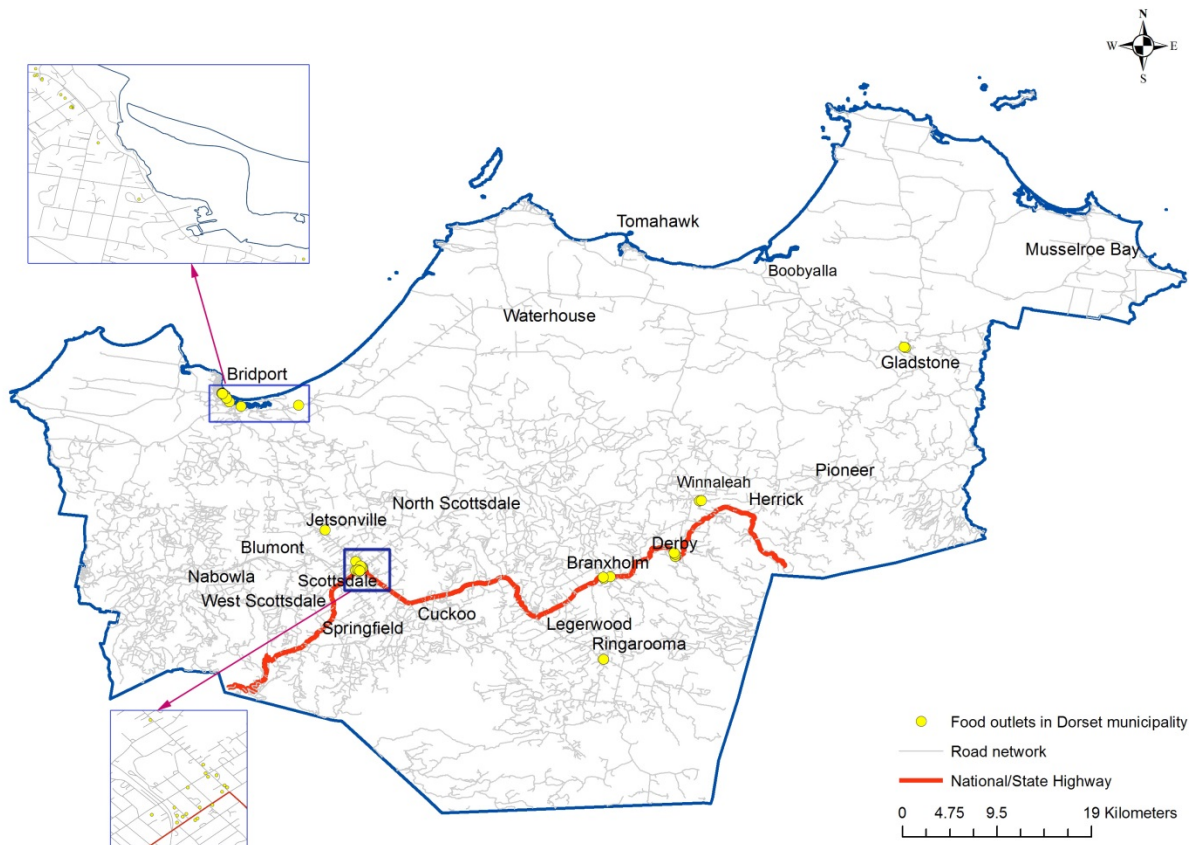
	Two parent family	Single parent family	Older person	Single adult
Total government social security payments per fortnight	\$1161.46	\$859.38	\$748.80	\$486.80
Amount and percentage of income required for THFB	\$503.95 (43%)	\$341.43 (40%)	\$120.86 (16%)	\$157.13 (32%)
Total average single household wage earned per fortnight	\$2422.00	\$2422.00	-	\$2422.00
Amount and percentage of income required for THFB	\$503.95 (21%)	\$341.43 (14%)	-	\$157.13 (6.5%)

Geographic access

In a municipality such as Dorset, where there is a higher level of social disadvantage and higher level of low-income individuals and families, poor geographical access to food outlets may create an additional layer of cost to the maintenance of a healthy diet. Additionally, infrastructure in Dorset, such as public transport, is not available. The following findings provide an overview of the situation around coverage and density of food outlets in Dorset.

Coverage

Map 1 below presents the roads and locations of the 48 identified food outlets in Dorset providing a practical visualization of physical access of the populations to them.

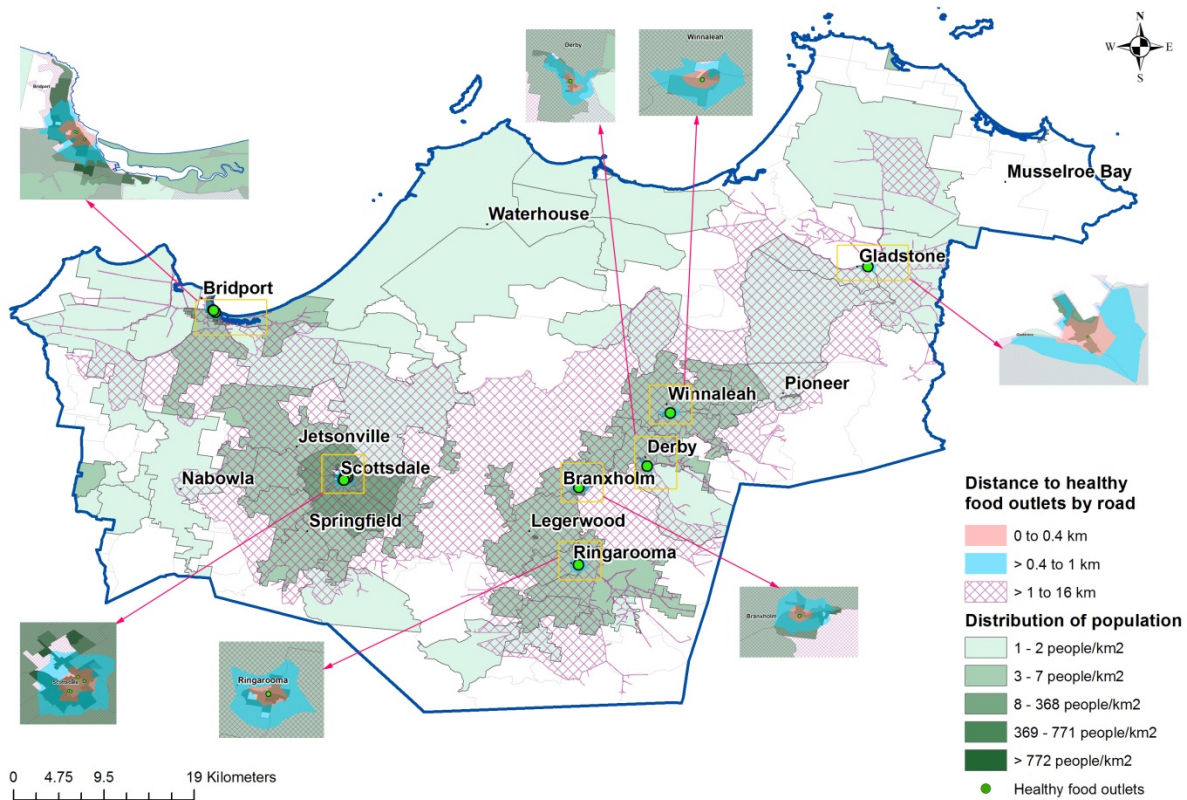


Map 1: Location of roads and all food outlets in Dorset municipality

A large number of the identified food outlets in Dorset were located alongside the National State Highway, which runs through the boundaries of some districts, townships or population centers, such as Scottsdale, North Scottsdale, Legerwood, Branhholm, Derby or Winnaleah, allowing them better access to food. Another large group of food outlets borders the north-west of Bridport suburb. The remaining outlets are scattered here and there on the borderlines of neighboring townships or population centers, causing variation in the extent of access to healthy food by inhabitants of Dorset municipality.

Map 2 shows the location and distribution of healthy food outlets by population density, with the darkest green representing neighborhoods of more than 772 people per square km. The findings revealed evidence of inequalities in healthy food access by populations of low and high density (Moran's Index=1.003, z-score=5.65, p-value=0.00 < 0.05).

The majority of healthy food outlets are concentrated in the darker shaded portions of the map, indicating that the more densely populated areas have better spatial access to healthy food than the sparsely populated areas. This may result from food retail providers usually targeting areas with larger markets for their products.



Map 2: Location of food outlets and population densities in Dorset municipality

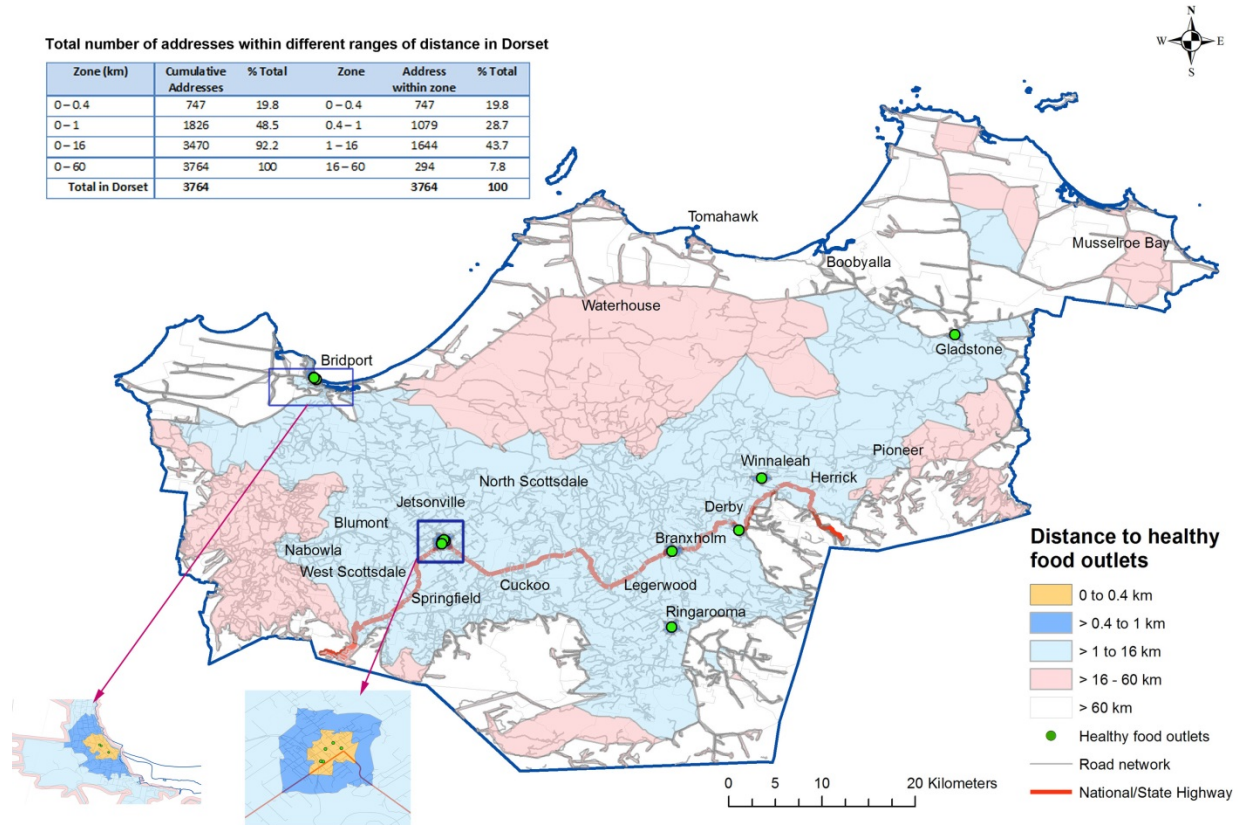
Density

The density of healthy food outlets in Dorset was determined with reference to an established rate of one healthy food outlet per 1,000 capita. Based on the food outlet audit process, 9 out of 48 food outlets in Dorset were identified as healthy food outlets. They consisted of one fruit and vegetable shop, three local/corner stores, two major supermarkets, and three minor supermarkets (grocers). Dorset is home to 6,834 people, with Scottsdale and Bridport representing the most populous townships or population centers (2,461 and 1,715 people, respectively) (ABS, 2013c). Thus there are 1.3 healthy food outlets per 1,000 people (i.e. 9 outlets for a total population of 6,834). This is slightly higher than the established threshold one per 1,000 for adequate access to healthy food.

However, 61.1% (4,176) of the Dorset population live within Scottsdale and Bridport towns, where four out of the nine healthy food outlets are found, representing 0.9 healthy food outlets per 1000 people and where ease of access to healthy food is greatest. Conversely, the remaining areas of the municipality contain the remaining 39.9% (2,658) of the population, with a rate of 1.88 healthy food outlets per 1000 people. Although this figure may be much higher than in Scottsdale and Bridport, there is a lower level of access among this population. Overall, these two population groups within the municipality may not be adequately served by healthy food outlets, either through greater distance to access for those living in rural areas, or lower number of food outlets to meet the demand in the more populated townships or population centers.

Proximity

Map 3 shows that 19.8% of the total number of addresses were within 400m of their nearest healthy food outlet i.e. within easy walking distance, while 28.7% were within moderate distance (400m-1km) and 51.5% were outside the 1km zone. Thus, approximately half of the households had limited walking access to healthy food. For the motorized populations, 294 households (7.8%) were outside the 16km zone and were therefore considered to have limited driving access to healthy food.



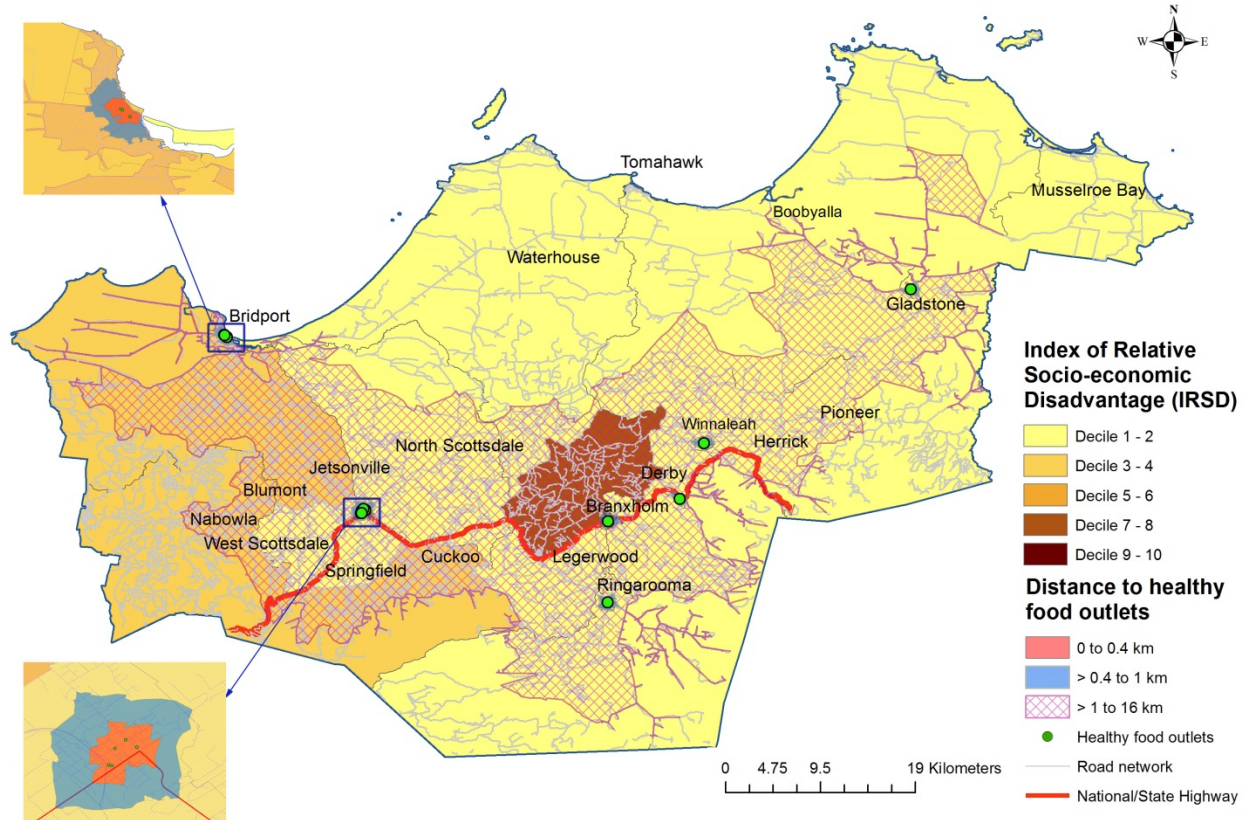
Map 3: Healthy food outlets in Dorset municipality and numbers of addresses within different ranges of distance from them

With the distribution of healthy food outlets on the borderlines of Bridport, Scottsdale, North Scottsdale, Legerwood, Branhholm, Derby or Winnaleah, a proportion of households surrounding these borderlines were in closer proximity to healthy food outlets (shown by areas of blue and yellow color/shading). On the other hand, a large proportion of areas in the townships or population centers of Waterhouse, Nabowla, Pioneer, Springfield, and Musselroe Bay were outside of the 16km zone of any healthy food outlets within Dorset (shown by areas of light blue and white color/shading). Households in these areas were identified as having poor or limited access to healthy foods even with the motorized populations. Those living in the areas of pink color/shading had limited walking access, but moderate driving access to healthy food.

As a whole, areas with easy access to healthy food in Dorset cover a much smaller proportion of the region than those with moderate and limited access, central areas having better access to healthy food than those on the periphery.

Geographic access and socio-economic disadvantage

In addition to geographical access, an additional layer was applied to identify areas where most socioeconomic disadvantage occurred relative to food outlets. Map 4 offers a visualization of the possible link between access to healthy food and socio-economic disadvantage. As shown in the brightest shading areas on the map, nine out of 14 townships or population centers in Dorset were in the first or second decile, representing the most disadvantaged areas, not only within Dorset, but also nation-wide. These townships or population centers with the highest relative socio-economic disadvantage (deciles 1 and 2) are Scottsdale, Ringarooma, Derby, Legerwood, Branhholm, Winnaleah, Pioneer, and Musselroe Bay. The remaining townships or population centers in darker shading were in deciles 3 and 4 (e.g., Nabowla, Springfield, Blumont, Cuckoo) and decile 5-6 (e.g. Bridport).



Map 4: Distribution of healthy food outlets in Dorset by Index of Relative Socioeconomic Disadvantage

A close examination of the distribution of healthy food outlets against the areas of different levels of socio-economic disadvantage in Dorset showed that healthy food outlets tended to be located in the more disadvantaged areas or districts (shown in brighter yellow shading). In other words, areas of higher disadvantage level in Dorset seemed to have higher geographic access to healthy food. On the contrary, the lower socio-economically disadvantaged districts such as Waterhouse and Springfield were completely devoid of healthy food outlets. Generally, the spatial distribution of healthy food outlets in Dorset tended to vary by area socio-economic status, favoring the more socio-economically deprived or disadvantaged areas (Moran's Index=0.924, z-score=5.187, p-value=0.00 < 0.05).

By definition, food deserts refer to areas where there are both physical and economic barriers to healthy food (Cummins & Macintyre, 2002; Guy & David, 2004; McEntee & Agyeman, 2010; Wrigley, et al., 2003). In this study, in order to determine the existence of food deserts in Dorset, the townships or population centers with the highest level of socio-economically disadvantage (those in deciles 1 and 2 as shown in the brightest yellow shading

on the map) were closely examined. The findings suggested that although the healthy food outlets were distributed mainly in the highly disadvantaged townships or population centers, the areas within easy and moderate walking access to healthy food outlets (within the 1km buffets, as shown in blue color) constituted a very small proportion. In contrast, the areas with limited walking access (outside the 1km buffets) in these highly disadvantaged townships or population centers, which are considered food deserts, took up approximately half of the Dorset region. The populations living in these so-called food deserts were faced with both geographic and economic limits such as travel-related costs for access to healthy food outlets and stand a higher risk of being food deprived. Although certain parts of these areas were reachable by the motorized populations (as shown in the checked shading), they were still classified as food deserts because low income populations usually find it hard to afford the cost associated with petrol and travel-related expenses.

Discussion

Food security is a complex challenge many people encounter on a day-to-day basis. The population of Dorset encounters many challenges to their nutritional needs, such as only 9 out of 48 food outlets in Dorset being classified as healthy and a lower food outlet to population ratio within the two major centers. Purchasing power is another challenge with one or two parent families spending 40-43% of government supported income in order to obtain healthy food. Many low income families also have inadequate geographical access to healthy food outlets.

Geographic access in Dorset

One of the most important revelations of the study about the geographic access to healthy food in Dorset is that there were varying extents of access to healthy food among the districts, favoring those in the central areas or those in close proximity to the national road. This suggests a link between food access and transport infrastructure. One possible explanation for this phenomenon is that better roads provide better logistic conditions for food supplies and the populations clustering around larger roads are potentially greater consumer markets for food outlets. This concentration of food outlets in central areas and around the national/state roads seem to reflect a universal trend where large retailers of food are normally located along highways or freeways, a practice dubbed “redlining” by Mamen (2007).

Another observation about geographic access to healthy food in Dorset is that the more densely populated areas tended to have better access to healthy food outlets than the sparsely populated areas. This is particularly an issue for those in the more remote communities, and indicative of the poorer access to healthy food of scattered populations. However, this finding also indicates that food outlet providers are responsive to population densities. Similar findings have been reported by other researchers (e.g., Schafft (2009)), whereby areas with higher density populations are provided with more supermarkets and grocery stores.

Regarding the density of healthy food outlets in Dorset, the rate of 1.3 healthy food outlets per 1,000 capita indicates an adequate level of density. However, spreading across a large area of 3,227 square km with a population density of 2.1 people per square kilometer, the population in Dorset is much more dispersed than in urban areas of other studies, which results in poorer proximity to healthy food outlets. For example, the findings on proximity showed that only around one fifth of the households in Dorset were within easy walking distance of healthy food outlets, about one third were within moderate walking distance and half had limited walking access. Poor access is a characteristic of rural areas in general (Morton & Blanchard, 2007).

Geographic food access and socio-economic disadvantage

In terms of the relationship between the distribution of healthy food outlets and socio-economic disadvantage, the study revealed a tendency of healthy food outlets to be located in the more disadvantaged areas or districts. This is consistent with reports by contemporary researchers worldwide in the field (Cummins & Macintyre, 2002; Macintyre, 2007; Pearce, et al., 2007). Cummins and Macintyre (2002), found large supermarkets were more likely

to be concentrated in deprived neighborhoods of Glasgow, UK and Pearce et al. (2007) in their nation-wide study in New Zealand, found that supermarkets and other healthy food shops were more accessible in more-disadvantaged neighborhoods. In America, Sharkey and Horel (2008) reported that the worst deprived neighborhoods had better spatial access to the nearest food store.

Commenting on the connection between spatial food access and socio-economic disadvantage, Pearce and his colleagues (2007) proposed two possible explanations, which are deemed relevant to the context of this study. Firstly, they argued that consumer demand is normally higher in more disadvantaged areas and thus attract food retailers. Besides, access to healthy food in adjacent higher advantaged areas will not be greatly affected because their residents are highly mobile and affluent. Secondly, population density is associated with neighborhood deprivation, which is clearly exemplified by the areas of Dorset in this study. It is quite easy to understand that there are more food outlets in the disadvantaged areas to serve their densely concentrated populations.

The identification of food deserts or areas with both physical and economic barriers to healthy food was one of the most significant outcomes of this study. Within the context of this study, food deserts were the areas having a socio-economic disadvantage score in the nationally lowest 2 deciles and were located outside the 1km zone along the road of any healthy food outlet. Food deserts covered about half of the Dorset region, which signifies an alarming incidence of areas threatened with food deprivation.

What this study adds

Many studies have indicated that there are spatial factors associated with food access and that those who are socially disadvantaged have less access to major supermarkets and pay more for their food. This is due to many factors such as higher cost of produce and cost of travel to outlets (2009; Burns & Inglis, 2007; DOH (WA), 2010; Jensen, et al., 2003; Meedeniya, et al., 2000; 2002; Northern Territory Government, 2008; Powell, et al., 2007; Queensland Health Treasury, 2000, 2006; Sharkey & Horel, 2008). Elements of these factors were found in a recent study of Dorset municipality (Le, et al., 2013) but, as found by Cummins and Macintyre (2002); Macintyre (2007); Pearce, et al. (2007); Sharkey and Horel (2008) there were no statistically significant differences in the mean quality scores for fresh fruit and vegetables between inner regional areas and outer regional areas. A further finding was that outer regional areas had more fruit and vegetable varieties to select from than inner regional areas of Tasmania (Le, et al., 2013). Proximity of residence is a critical factor in determining choice of food outlets in the municipality, which is more important than value for money or accessing a particular variety of food on sale. Transport is therefore the pivotal factor in determining food outlet choice and access to healthy food.

Implications for policy

The creation of environments in which all communities have ready access to food outlets, providing a range of affordable and appropriate healthy food, requires action at strategic and policy levels. In order to achieve this, particularly in areas designated as food deserts, the following are recommended:

- Community and public transport systems be established to support the community's capacity to acquire a diverse range of healthy food. Within Dorset, private cars are the most used transport method to access food and those without private transport have limited choice of where to shop. It is important, therefore, that infrastructure development and regional planning work hand-in-hand with food security policy at the outer regional and remote level.
- The promotion of local produce and food access initiatives that support the ongoing development of social enterprise concerning food security activities. These include increased farm gate sales, farmers' markets, food cooperatives, group buying and growing and swapping produce within communities.
- Recognition of the role and importance of farmers and food growers in maintaining a sustainable food security system, the importance of planning urban and agricultural land use and the need to engage the food

industry sectors and food retailers in outer regional and remote planning to ensure adequate and equitable access to healthy food.

Conclusion

To conclude, the study has achieved all of its objectives, including quantifying and visualizing geographic access to healthy food; examining healthy food access in relation to socio-economic disadvantage status; and determining the existence of food deserts in the regional area of Dorset, Tasmania, Australia. The concentration of healthy food outlets in the central areas of Dorset, areas in proximity to the national road, areas of more dense populations, and areas of higher disadvantage level are some of the most important findings of the study. In addition, the spatial identification of food deserts has been a pioneering attempt to visualize areas with the highest demand for improvement in healthy food access. The findings of the study have contributed to building a more evidence-based understanding of the spatial and environmental aspects of healthy food access in the municipality of Dorset, which may be applicable to areas with similar characteristics elsewhere. It also offers a useful reference for policymaking and strategy building related to the promotion of access to healthy food.

Acknowledgements

We would like to acknowledge Tasmanian Government Department of Premier and Cabinet (DPAC) which provided funding for this study through the Tasmanian Food Security Council. We would also like to thank residents of the Dorset Municipal Council who generously gave their time to participate in the study. Special thanks must also go to the Dorset Council for assisting with the delivery of the study within their respective municipal council area.

References

- ABS. (2011a). 1270.0.55.001 - Australian Statistical Geography Standard (ASGS): Volume 1 - Main Structure and Greater Capital City Statistical Areas, July 2011 Retrieved July 2013, 2013, from <http://www.abs.gov.au/AUSSTATS/abs@.nsf/DetailsPage/1270.0.55.001July%202011>
- ABS. (2011b). Statistical Geography - Australian Standard Geographical Classification (ASGC), Digital Boundaries Retrieved 15 January, 2012, from <http://www.abs.gov.au/AUSSTATS/abs@.nsf/DetailsPage/1259.0.30.0022006>
- ABS. (2011c). Statistical Geography - Australian Standard Geographical Classification (ASGC), Digital Boundaries , 2006 Retrieved 15 January, 2012, from <http://www.abs.gov.au/AUSSTATS/abs@.nsf/DetailsPage/1259.0.30.0022006>
- ABS. (2012a). Average Weekly Earnings, Australia. (*cat. no. 6302.0*) Retrieved 31 January, 2012, from <http://www.abs.gov.au/ausstats/abs@.nsf/mf/6302.0.55.003>
- ABS. (2012b). Regional Population Growth, Australia, 2010-11, from <http://www.abs.gov.au/ausstats/abs@.nsf/Products/3218.0~2010-11~Main+Features~Tasmania?OpenDocument>
- ABS. (2013a). 2033.0.55.001 - Census of Population and Housing: Socio-Economic Indexes for Areas (SEIFA), Australia Retrieved 18 August, 2013, from <http://www.abs.gov.au/AUSSTATS/abs@.nsf/DetailsPage/2033.0.55.0012011?OpenDocument>
- ABS. (2013b). 2033.0.55.001 - Census of Population and Housing: Socio-Economic Indexes for Areas (SEIFA), Australia, 2011 Retrieved 28 July, 2013, from <http://www.abs.gov.au/AUSSTATS/abs@.nsf/DetailsPage/2033.0.55.0012011?OpenDocument>

- ABS. (2013c). Census for a brighter future - Data and analysis Retrieved 18 July 2013, 2013, from <http://www.abs.gov.au/websitedbs/censushome.nsf/home/data?opendocument&navpos=200>
- Adu-Nyako, K. (2011). *Community food store types availability is associated with fruit and vegetable consumption in North Carolina*. Paper presented at the Southern Agricultural Economics Association Annual Meeting, Texas.
- AIHW. (2011). Remoteness classifications Retrieved 8th January 2011, from <http://www.aihw.gov.au/ruralhealth/remotenessclassifications/index.cfm>
- Apparicio, P., Cloutier, M. S., & Shearmur, R. (2007). The case of Montreal's missing food deserts: Evaluation of accessibility to food supermarkets. *International Journal of Health Geographics*, 6, -. doi: Artn 4 Doi 10.1186/1476-072x-6-4
- Australia's Farmers' Markets association. (2013). Australia's Farmers' Markets Directory Retrieved 1 June, 2013, from <http://www.farmersmarkets.org.au/markets#tas>
- Ball, K., Timperio, A., & Crawford, D. (2009). Neighbourhood socioeconomic inequalities in food access and affordability. *Health Place*, 15(2), 578-585.
- Besharov, D. J., Bitler, M., & Haider, S. J. (2011). An economic view of food deserts in the united states. *Journal of Policy Analysis and Management*, 30(1), 153-176.
- Block, J., Scribner, R., & DeSalvo, K. (2004). Fast food, race/ethnicity, and income: a geographic analysis. *American Journal of Preventative Medicine*, 27(3), 211-217.
- Bodor, J. N., Rose, D., Farley, T. A., Swalm, C., & Scott, S. K. (2008). Neighbourhood fruit and vegetable availability and consumption: the role of small food stores in an urban environment. *Public Health Nutrition*, 11(4), 413-420.
- Burns, C. M., & Inglis, A. D. (2007). Measuring food access in Melbourne: Access to healthy and fast foods by car, bus and foot in an urban municipality in Melbourne. *Health & Place*, 13(4), 877-885. doi: DOI 10.1016/j.healthplace.2007.02.005
- Clarke, G., Eyre, H., & Guy, C. (2002). Deriving indicators of access to food retail provision in British cities: Studies of Cardiff, Leeds and Bradford. *Urban Studies*, 39(11), 2041-2060.
- Clifton, K. (2004). Mobility strategies and food shopping for lowincome families. *J Plann Educ Res*, 23(4), 402-413.
- Cummins, S., & Macintyre, S. (2002). A systematic study of an urban foodscape: the price and availability of food in Greater Glasgow. *Urban Studies*, 39(11), 2115-2130.
- Department of Health. (2014). Australian Guide to Healthy Eating Retrieved 2 January, 2014, from <https://www.eatforhealth.gov.au/guidelines/australian-guide-healthy-eating>
- DOH (WA). (2010). Food Access and Costs Survey (FACS) Retrieved 20 September, 2011, from <http://www.public.health.wa.gov.au/cproot/4115/2/Food%20Access%20and%20Costs%20Survey%202010.pdf>
- DPIPWE. (n.d.). Vector Data: Base data from theLIST (www.thelist.tas.gov.au) - (Vol. 2011). In W. a. E. Department of Primary Industries (Ed.). Hobart: TheLIST: State of Tasmania.
- Eat Well Tasmania. (2013). Eat Well Grow Well Project Retrieved 1 June, 2013, from <http://www.eatwelltas.org.au/gardening.php>
- FAO. (1996). *Rome Declaration on World Food Security and World Food Summit Plan of Action*. Rome.
- Fruit Growers Tasmania. (2012). Farm Gate Guide 2011-2012, 1 June, from <http://www.cherrygrowers.org.au/assets/FarmGate2013LowRes.pdf>
- GeoScience Australia. (2012). Geoscience Portal Retrieved 26 April, 2012, from <http://http://www.geoscience.gov.au/>
- Guy, C. M., & David, G. (2004). Measuring physical access to 'healthy foods' in areas of social deprivation: a case study in Cardiff. *International Journal of Consumer Studies*, 28(3), 222-224.
- Hattori, A., An, R., & Sturm, R. (2013). Neighborhood food outlets, diet, and obesity among California adults. *Preventing Chronic Disease*, 10, 120-123. doi: <http://dx.doi.org/10.5888/pcd10.120123>

- Jensen, L., McLaughlin, D. K., & Slack, T. (2003). Rural poverty: the persisting challenge. In D. L. Brown & L. E. Swanson (Eds.), *Challenges for rural America in the twenty-first century* (pp. 118–131). University Park, PA: The Pennsylvania University Press.
- Larsen, K., & Gilliland, J. (2008). Mapping the evolution of 'food deserts' in a Canadian city: Supermarket accessibility in London, Ontario, 1961-2005. *International Journal of Health Geographics*, 7, -. doi: Artn 16 Doi 10.1186/1476-072x-7-16
- Le, Q., Murray, S., Long, G., Auckland, S., Etchells, T., Flanagan, J., . . . Schulz, S. (2013). Tasmanian food access research coalition TFARC: Research report. Hoabrt: Tasmanian Food Access Research Coalition.
- Lee, G., & Lim, H. (2009). A spatial statistical approach to identifying areas with poor access to grocery foods in the city of buffalo, New York. *Urban Studies*, 46(7).
- Lee, H. (2012). The role of local food availability in explaining obesity risk among young school-aged children. *Social Science & Medicine*. doi: doi:10.1016/j.socscimed.2011.12.036
- Macdonald, L., Cummins, S., & Macintyre, S. (2007). Neighbourhood fast food environment and area deprivation—substitution or concentration? *Appetite*, 49(1), 251–254.
- Macintyre, S. (2007). Deprivation amplification revisited; or, is it always true that poorer places have poorer access to resources for healthy diets and physical activity? . *International Journal of Behavioral Nutrition and Physical Activity*, 4(32).
- Mamen, K. (2007). Facing Goliath: Challenging the impacts of supermarket consolidation on our local economies, communities, and food security. *Policy Brief, The Oakland Institute*, 1(3), 1-8.
- McCluskey, K. (2009). Food security in Moreland: A needs assessment. Melbourne: Merri Community Health Services.
- McEntee, J., & Agyeman, J. (2010). Towards the development of a GIS method for identifying rural food deserts: Geographic access in Vermont, USA. *Applied Geography*, 30(1), 165-176. doi: DOI 10.1016/j.apgeog.2009.05.004
- Meedeniya, J., Smith, A., & Carter, P. (2000). Food Supply in Rural South Australia: A Survey on Food Cost, Quality and Variety. South Australia: Eat Well SA.
- Moreland, K., Wing, S., Diez Roux, A., & Poole, C. (2002). Neighborhood characteristics associated with the location of food stores and food service places. *American Journal of Preventive Medicine*, 22(1), 23-29.
- Morton, L. W., & Blanchard, T. C. (2007). Starved for access: Life in rural America's food deserts. *Rural Sociological Society*, 1(4), 1-5.
- Northern Territory Government. (2008). NT Market Basket Survey 2008. Northern Territory: Department of Health and Family, Northern Territory Government
- Pearce, J., Blakely, T., Witten, K., & Bartie, P. (2007). Neighborhood deprivation and access to fast-food retailing - A national study. *American Journal of Preventative Medicine*, 32(5), 375-382.
- Powell, L. M., Auld, M. C., Chaloupka, F. J., O'Malley, P. M., & Johnston, L. D. (2007). Associations between access to food stores and adolescent body mass index. *American Journal of Preventive Medicine*, 33(4), S301-307.
- Queensland Health Treasury. (2000). The Healthy Food Access Basket Survey 2000: Queensland Health Treasury
- Queensland Health Treasury. (2006). The 2006 Health Food Access Basket survey Retrieved 08 August, 2011, from <http://www.health.qld.gov.au/ph/documents/hpu/33125.pdf>
- Raja, S., Ma, C. X., & Yadav, P. (2008). Beyond food deserts - Measuring and mapping racial disparities in neighborhood food environments. *Journal of Planning Education and Research*, 27(4), 469-482. doi: Doi 10.1177/0739456x08317461
- Rose, D. (2010). Access to Healthy Food: A Key Focus for Research on Domestic Food Insecurity. *The Journal of Nutrition*, 1167-1169.

- Rychetnik, L., Webb, K., Story, L., & Katz, T. (2003). Food Security Options Paper: A food security planning framework: A menu of options for policy and planning interventions: NSW Centre for Public Health Nutrition, NSW.
- Schafft, K. A., Jensen, E. B., & Hinrichs, C. C. (2009). Food Deserts and Overweight Schoolchildren: Evidence from Pennsylvania. *Rural Sociology*, 74(2), 153-177.
- Sharkey, J. R., & Horel, S. (2008). Neighborhood socioeconomic deprivation and minority composition are associated with better potential spatial access to the ground-truthed food environment in a large rural area. *Journal of Nutrition* 138(3), 620-627.
- Sparks, A., Bania, N., & Leete, L. (2009). *Finding food deserts: Methodology and measurement of food access in Portland, Oregon*. Paper presented at the The National Poverty Center/USDA Economic Research Service research conference, Washington DC.
- Wrigley, N., Warm, D., & Margetts, B. (2003). Deprivation, diet and food retail access: Findings from the Leeds 'food deserts' study. *Environment and Planning A*, 35(1), 151-188.