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EXPLORING THE SPATIAL DISTRIBUTION OF ABORIGINAL FOOD SECURITY AND INSECURITY IN NEW SOUTH WALES USING SURVEY AND CENSUS DATA

Y. DINKU, C. WALSH, F. MARKHAM AND C. PURI

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ANU College of
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Professor Valerie Cooms
Director, CAEPR
Research School of Social Sciences
College of Arts & Social Sciences
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Yonatan Dinku is a Research Fellow
at the Centre for Aboriginal Economic
Policy Research (CAEPR), Research
School of Social Sciences (RSSH),
College of Arts & Social Sciences,
Australian National University.

Corinne Walsh is a Research Fellow
at the Centre for Social Research and
Methods, RSSH. **Francis Markham**
is a Research Fellow at CAEPR.

Chase Puri is a Senior Data Insights
Analyst at Aboriginal Affairs NSW.

Exploring the spatial distribution of Aboriginal food security and insecurity in New South Wales using survey and Census data

Y. Dinku, C. Walsh, F. Markham and
C. Puri

Abstract

This study presents estimates of the prevalence of food insecurity among Aboriginal and Torres Strait Islander households in small geographical areas in the state of New South Wales (NSW). Using the 2018-19 National Aboriginal and Torres Strait Islander Health Survey (NATSIHS) and 2021 Census of Population and Housing, the research investigates the factors associated with food security in Aboriginal households and estimates the prevalence of food insecurity at the Statistical Area 2 (SA2) level across NSW. Logistic regression results reveal associations between household food insecurity and income, financial stress, household size, housing tenure, food preparation facilities, and remoteness.

Notably, the study finds that food insecurity is driven primarily by financial resources rather than access to grocery stores. The research highlights the prevalence of going without food in urban parts of NSW for Indigenous households relative to non-metropolitan areas, and suggests a concentration of food insecurity among Indigenous populations in urban and inner regional areas. Maps of the predicted prevalence of food insecurity across NSW are provided.

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Acronyms

AMSANT	Aboriginal Medical Services Alliance Northern Territory
ANU	Australian National University
CAEPR	Centre for Aboriginal Economic Policy Research
NATSIHS	National Aboriginal and Torres Strait Islander Health Survey
NRHA	National Rural Health Alliance
OR	Odds Ratio
SA2	Statistical Area 2
SES	Socioeconomic Status

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Introduction

This paper sets out estimates of the prevalence of food insecurity among Aboriginal and Torres Strait Islander people in NSW in local geographical areas. Food insecurity is a social and health concern for Aboriginal and Torres Strait Islander people in NSW, and has been reported in qualitative research to be ‘a huge problem experienced... on a regular basis’ (Sheriff et al., 2022: 11). Food security is commonly defined as encompassing the continuous physical, social, and economic access to sufficient, safe, and nutritious food for all individuals, satisfying their dietary preferences and requirements for an active, healthy life (United Nations' Committee on World Food Security, 2012). Conversely, food insecurity emerges when access to nutritionally adequate, safe, and socially acceptable food is limited or uncertain (Committee on World Food Security, 2012, as cited in Bowden, 2020). The Food and Agriculture Organization of the United Nations (2006) and the World Health Organization (2011) identify four dimensions of food security: availability, access, utilization, and stability. Warr (2014) also discerns four levels of food (in)security: global, national, household, and individual. Achieving food security necessitates more than a mere abundance of food; it requires access to high-quality, nutritionally sufficient, socially and culturally appropriate, and safe sustenance (Radimer, 2002). Having access to culturally appropriate food means that people have access to food that aligns with a person's traditions, customs, and ways of life. Nutritious food is essential for maintaining physical and mental wellbeing, as well as for preventing illness and disease, especially among children (Sherriff et al., 2022; Spurway & Soldatic, 2016; Davy, 2016; Bowden, 2020).

AMSANT's *Food Security in the Northern Territory Discussion Paper* describes what food security means from an Indigenous perspective:

The land and the sea is our food security. It is our right. Food security for us has two parts: Food security is when the food from our ancestors is protected and always there for us and our children. It is also when we can easily access and afford the right non-traditional food for a collective healthy and active life. When we are food secure we can provide, share and fulfil our responsibilities, we can choose good food, knowing how to make choices and how to prepare and use it (2021:5).

Aboriginal and Torres Strait Islander people in NSW, like Indigenous peoples throughout Australia, are particularly likely to find themselves in food insecure circumstances. Constrained incomes, high food costs, and barriers to accessing fresh and nutritious food through commercial or customary sources are reported to contribute to Aboriginal and Torres Strait Islander food insecurity in NSW (Davies et al., 2022). Nationally, when last measured in a representative population survey, approximately 26% of Indigenous people reported living in a household that had run out of food and could not afford to buy more at least once in the previous twelve months (Markham & Kerins, 2020). By way of comparison, the last national survey that asked a comparable question of all Australians found that 4% of people lived in a household that, in the previous 12 months, had run out of food and could not afford to buy more. At the national level, it is often noted that Indigenous food security is correlated with remoteness, with experiences of food insecurity among Indigenous households more likely to be reported in this survey in very remote parts of Australia (where 43% of Indigenous people reported experiencing this form of food insecurity in the previous 12 months) than major cities (where 21% of Indigenous people reported experiencing this form of food insecurity). Given the frequency with which experiences of food insecurity are reported by Aboriginal and Torres Strait Islander people living in urban areas, food insecurity should not be interpreted as solely being a regional or remote issue (Fredricks & Bradfield, 2021). To date, however, the extent of Aboriginal and Torres Strait Islander food security in NSW specifically has not been documented (Davies et al., 2022).

Relatively little research has examined Aboriginal and Torres Strait Islander peoples' experiences of food security and insecurity in NSW. A recent systematic review identified only three studies on the extent and

distribution of Aboriginal and Torres Strait Islander food security in NSW specifically (Follent et al., 2021; Miller et al., 2020; Sherriff et al., 2022; see Davies et al., 2022). The authors of the review noted that while ‘Aboriginal and Torres Strait Islander Australians are experiencing food insecurity [in NSW]... the scale and distribution is unknown’ (Davies et al., 2022, p. 25). More generally in Australia, few studies have examined the distribution of Indigenous food security and insecurity systematically at local geographical scales. Studies have tended to either use coarse spatial categorisations (such as ‘remoteness’ or state/territory boundaries) when relying on survey data, or focus exclusively on case studies in one or two localities, particularly when using qualitative methods. In general, studies have not adopted methods that make it possible to compare the prevalence of Indigenous food security in particular localities with any degree of confidence. A standardised methodological approach in which the prevalence of food security and insecurity is estimated using consistent methods and data across small geographical areas is needed so that such comparisons can be made. This is important because an understanding of *where* people are facing food insecurity can help in distributing services such as emergency food relief.

Furthermore, both academic research (e.g. Markham & Kerins, 2020; Altman & Markham, 2022) and government inquiries (e.g. House of Representatives Standing Committee on Indigenous Affairs, 2020) have tended to emphasise remote communities as a setting of concern. This is perhaps unsurprising given the prevalence of remote food security in the national statistics cited above. However, it has had the unfortunate consequence that Indigenous food security in urban areas receives less attention within research and remains an under-investigated topic’ (Fredricks & Bradfield, 2021, p. 56). Consequently, this paper focuses on food insecurity in urban, regional and remote NSW.

This study has developed a methodology for estimating the prevalence of Indigenous food security and insecurity at local geographical scales, using the state of NSW as our case study. Specifically, we use a small-area estimation methodology to combine a household survey-based model of Indigenous food insecurity with supplementary spatial data and microdata from the 2021 Census of Population and Housing to estimate the prevalence of Indigenous food insecurity in 595 Statistical Area 2 (SA2) spatial units across NSW. We rely on two questions about food security asked in the ABS’s population representative survey, the National Aboriginal and Torres Strait Islander Health Survey (NATSIHS) 2018–2019, to measure food insecurity in our small-area models. Before proceeding to these models, we first review the literature on Indigenous food security in Australia. We pay particular attention to studies of the social and spatial patterning of food security and insecurity to inform our modelling approach.

Previous studies of the social and spatial distribution of Indigenous food security in NSW and Australia

A small literature focused on Aboriginal and Torres Strait Islander people in Australia has explored the social and spatial distribution of food security and insecurity. In NSW in particular, the geographical context of this paper, very few studies of Aboriginal and Torres Strait Islander food security have been undertaken (Davies et al., 2022). Key findings from this literature are grouped thematically below. We focus on studies of Indigenous food security in NSW where possible, drawing on the broader Australian literature to deepen this thematic review.

Spatial distribution

It is widely reported that those who are socially isolated or living in geographically remote areas are most vulnerable to food insecurity (see Bowden 2020:2; Rosier 2011:25; Temple 2018:1; Markham & Kerins, 2020).

According to Temple and Russell, geography was highly associated with exposure to food insecurity, at least for older Aboriginal and Torres Strait Islander people:

we observe differences in exposure to food insecurity by discrete categories of English language speaking and geography. In this sample, almost all respondents in non-remote areas speak English in the household. Approximately 19% of this group were food insecure, as were those who spoke English in remote areas of Australia. However, for those who speak Indigenous languages residing in remote areas, the prevalence of food insecurity was almost double (about 37%). Indeed, 12% of Indigenous language speakers in remote areas were severely food insecure (or one third of all food insecure people) (2018:4).

According to the National Aboriginal and Torres Strait Islander Health Survey, Indigenous people in remote areas of Australia were more likely to run out of food than those in non-remote areas (31 per cent and 20 per cent respectively), and somewhat more likely to go without food (9.2 per cent and 6.4 per cent respectively, cited in NRHA, 30 June 2020).

However, this does not necessarily mean that those living in urban areas are protected from food insecurity (Fredricks & Bradfield, 2021). Rosier, quoting Browne et al (2009), reports that – while rates of food insecurity are highest in remote communities – Indigenous people living in urban environments are also vulnerable to food insecurity, due to poor income, household infrastructure and overcrowding, access to transport, storage and cooking facilities (Rosier 2011:26).

In NSW, no published studies have reported on the prevalence of food security in different areas (Davies et al., 2022). But within some other Australian jurisdictions, few regional patterns are evident. For example, in Markwick et al's 2014 study of the relationship between food insecurity and Aboriginal and Torres Strait Islander status in the state of Victoria, rurality was *not* associated with food insecurity (2014:3). This stands in contrast with the national correlation with remoteness described above. It seems that spatial patterns in food security and insecurity are contextually sensitive and may vary from jurisdiction-to-jurisdiction. Consequently, studies of specific jurisdictions like NSW are important, as national scale patterns may not necessarily apply within all states and territories.

Access to food is geographically patterned. Sherriff et al. (2022: 2) note that:

food environments and food insecurity experienced by Aboriginal and Torres Strait Islander people in non-remote Australia also differ from those experienced in remote areas. While the urban food environment may offer a tremendous diversity of food for consumers, there are huge geographical disparities in access to fresh, healthy food, determined by the socioeconomic status (SES) of each region (2022:2).

Furthermore, Customary provisioning of food through hunting, fishing and harvesting activities are particularly important to many Aboriginal and Torres Strait Islander people, but this relies on access to land and sea country. Country suitable for customary food provisioning may be more easily accessed by those outside of major cities.

It appears, then, from the literature reviewed above, that food insecurity is not confined to just remote/isolated areas, nor to just urban areas. Rather, as Sherriff et al suggest above, food insecurity risk is perhaps more about the socio-economic status of a household and the town/area/region in which they live, rather than simply remoteness alone.

Economic, social and cultural influences on food security and insecurity

Income and socio-economic status

Income is closely related to food security. Adequate income is consistently correlated with food security, and low income is consistently mentioned as the main factor associated with food insecurity, (Miller & Li 2022:18; Bowden 2020:2; Bhawra et al 2015; Leroux et al 2018; Spurway and Soldatic 2016; Muthayya et al 2020; Temple 2018:1; Godrich et al 2017:585; Hughes et al 2011:27; McCarthy et al 2018). Sherriff et al conducted semi-structured interviews with 44 people (Aboriginal and non-Aboriginal community members and stakeholders) from two Aboriginal communities (one urban and one regional) in NSW, to get their perspectives on food insecurity. All participants felt strongly that food insecurity was a major problem in their communities, and that Aboriginal families are experiencing food insecurity on a regular basis. 'Trapped in financial disadvantage' was one of the major factors contributing to food insecurity. As Sherriff writes: "Participants felt families were running out of money before each pay cycle and were unable to purchase food, which was further intensified for single parent or single income families. They noted these financial struggles were due to high rates of unemployment and low income..." (2022:5). Low income and financial disadvantage typically leads to a reliance on more affordable, longer-lasting, energy-dense, nutrient-poor foods (Bhawra et al 2015:1). In their study in urban and regional NSW, Miller et al. (2020) find that Aboriginal parents' and carers' report that the affordability of food is an important impediment to their ability to provide their children with fresh and healthy food. In Sherriff et al's research, financial disadvantage led Aboriginal people in both communities to purchase and consume cheap, non-nutritious, filling substances such as processed meats, white bread, takeaway, fried foods, and packet and tinned foods, particularly if they have big families (2022:2). Pollard et al conducted a study with remote community store managers to obtain their views of community food insecurity, and these managers reported high unemployment and low household income, resulting in lack of money, amongst community members as the main reasons (2014:83).

The situation is comparable elsewhere. Markwick et al's 2014 study in the state of Victoria confirms the importance of income, finding that 'the lower the household income the higher the odds ratio (OR) of food insecurity, with those in the lowest household income bracket (\$20,000 or less) being 8.4 times more likely to have experienced food insecurity compared with those in the highest household income bracket (greater than \$80,000)' (2014:7-8). Similarly, McCarthy et al interviewed 30 Aboriginal and Torres Strait Islander primary-caregivers who have young children, in the urban towns of Darwin and Palmerston in the Northern Territory in 2018. The aim was to investigate factors that influence household food security, as well as coping strategies used. These researchers also found that food affordability relating to income and living expenses was a major barrier to a healthy diet, with large household bills impacting food choice and meal quality. According to McCarthy et al, food insecurity is largely experienced intermittently by Aboriginal and Torres Strait Islander families, occurring especially when large household bills are due for payment (2018:1).

Several authors argue that food insecurity is more common among those relying on the social security system. In Temple et al.'s (2019) national study which included respondents in NSW, measures of financial wellbeing were examined among food-insecure Indigenous households in receipt of social assistance payments. Results indicated that food-insecure households in receipt of social assistance payments endured significant financial stress, with a large proportion co-currently experiencing "fuel" or "energy" poverty.

Cost of food

The flipside of income is expenditure. Food—especially fresh, nutritious foods such as fruit and vegetables—has long been relatively expensive in regional and remote towns and communities. In regional and remote communities, the costs of delivering and refrigerating fresh food is relatively high, competition among retailers is

low, and economies of scale are non-existent. Market basket studies conducted in NSW in 2006, 2008 and 2009 have found that food is more expensive in remote locations, with a price differential of around 7% reported between stores in remote and highly accessible NSW in 2006 (Chapman et al., 2014). Furthermore, fewer varieties of fresh fruit and vegetables were available in remote stores compared with urban stores. This is consistent with findings in other jurisdictions (e.g. Ferguson et al 2018). The elevated price of food, and reduced range of available fresh fruit and vegetables, may contribute to food insecurity in remote areas, including Aboriginal and Torres Strait Islander people (Rosier 2011:25; Bowden 2020:2; Markham & Kerins 2020).

The literature illustrates the relationship between high food prices and food insecurity in Indigenous communities. For example, in Sherriff et al's qualitative study with Aboriginal community members and stakeholders in an urban and a regional location in NSW, participants described the unavailability of healthy food options, both in terms of takeaway shops and supermarkets in the suburbs where most Aboriginal families live i.e. it is mostly tinned, packet and processed (and thus largely unhealthy) foods (2022:7). Even though healthy, nutritious food is more regularly available at larger supermarkets, it was still unaffordable for many family budgets. Instead of good quality meat, for instance, participants instead purchased and consumed cheap meats such as mince, sausages, processed meat such as devon to make their dollars go further (2022:6-7).

Kinship, sharing and reciprocity

Sharing food and resources among kin is a primary means for strengthening food security in Indigenous communities, especially in the face of low incomes and high-cost food. Participants in Sherriff et al's qualitative study with Aboriginal community members from an urban and regional area in NSW discussed the unique kinship networks, and values of sharing and reciprocity, that exist in Aboriginal cultures. They explained that this means families are often providing food and resources not just to people within their household but amongst their extended family and wider kinship and community networks, which is not typical amongst non-Aboriginal people (2022:11). The sharing of food, money and resources amongst family and the wider Aboriginal community was the main way in which people dealt with food insecurity, and was overwhelmingly viewed as a positive cultural factor (Sherriff et al 2022:11).

Other studies with Aboriginal populations elsewhere in Australia have also highlighted the positive role of family and community relationships when it comes to sharing money and food with families struggling with food insecurity (e.g. Browne et al 2009). For example, McCarthy et al interviewed 30 Aboriginal and Torres Strait Islander primary-caregivers who have young children in the urban towns of Darwin and Palmerston in the Northern Territory, with the aim of investigating factors that influence household food security, as well as coping strategies used. Access to family support was the main reported coping strategy to deal with food insecurity (McCarthy et al 2018:1). This finding led McCarthy et al to conclude that "family support provides an essential safety net and the implications of this are important to consider in public policy to address food insecurity" (2018:1). Similarly, Altman (2018:187) writes that sharing bush food and cash unsolicited remains a fundamental feature of life for Kuninju people. It is both an economic institution that strengthens food security, and is simultaneously a cultural practice that is 'regarded as demonstrating the very best of Kuninju relational norms and values.'

Customary provisioning and food sovereignty

Several authors position food sovereignty as a strategy to better food security for Indigenous peoples in the sources analysed as part of this literature review. That is, Indigenous people being able to freely access country and bush foods; to use customary food acquisition methods; and to practice traditional/customary knowledge and values surrounding food (Fredericks & Bradfield 2021:55). Essentially, enabling Indigenous people to be self-determining when it comes to food and its use.

Participants in Spurway and Soldatic's research, for example, consistently reported that they coped with food insecurity by fishing and crabbing on their traditional lands, "in country" (2016:1118). Markham and Kerins (2020:iii) argue that removing barriers impeding Indigenous peoples from pursuing customary food provisioning will help increase food security. In NSW, Hunt and Ridge (2022) report that the prosecution of Aboriginal fishers on the South Coast of NSW for exercising their customary rights to fishing is restricting the food security of Aboriginal people.

Household composition, single parenthood, and gender

Several studies have found that household composition influences household food security. Temple and Russell's national study have found that — consistent with previous Australian studies — reporting food insecurity was about 60% less likely for those who were married (relative to the unmarried) (2018:8). Household size was associated with food insecurity in Markwick et al's study (2014:4), though Markwick et al do not discuss this in depth in their paper.

Furthermore, Australian studies that focus on the general population have found that single parent households are particularly susceptible to food insecurity (Burns 2004 in Rosier 2011:25; Markwick et al 2014:4; Bowden 2020:2). Given that 2021 Census data indicates that one third of Aboriginal and Torres Strait Islander one-family households in NSW are single parent households, this general finding is likely to be particularly applicable to Indigenous people (ABS 2021). In a qualitative study to explore food security and the profile of/experiences of people using food aid in Victoria, McKay et al found that 73.1% of the 78 participants who utilise food aid organisations/charities were female (2020:1). Markwick et al's 2014 study to explain the relationship between food insecurity and Aboriginal and Torres Strait Islander status in the state of Victoria reveals that food insecurity is more likely to be experienced by females than males (2014:3).

Housing

Infrastructure and facilities — such as a working stove, oven, fridge, freezer — may be lacking in certain communities and households (Torzillo et al 2008; Sherriff et al 2022:8). In Sherriff et al's qualitative study with Aboriginal community members and stakeholders in an urban and a regional location in NSW, participants also expressed that some community members do not have access to basic cooking and food storage facilities such as a fridge or a freezer. This is a major barrier to being able to prepare, store and eat fresh healthy meals (2022:8). Rosier explains that "one survey of almost four thousand Indigenous homes in the Northern Territory found that only 38% had facilities such as stoves, ovens, running water and adequate storage for food (Bailie & Runcie, 2001). This further encourages a reliance on ready-made, and often nutritionally-poor foods" (Rosier 2011:25).

Summary

Food insecurity remains an issue across the country, especially for Aboriginal and Torres Strait Islander people. When disaggregated by remoteness for the whole country, Indigenous people living in remote areas report a greater degree of food insecurity compared to those in regional and urban areas. However, these geographical patterns appear to vary between jurisdictions. Consequently, there is value in jurisdictional studies as broad-brush generalisations about remoteness may not apply across all parts of Australia.

At the household and individual level, the main predictors of food security and insecurity for Indigenous people include income and socioeconomic advantage and disadvantage, the cost of food locally, networks of kinship and sharing which protect against hunger, access to land to undertake customary provisioning, household composition, and dwelling quality. The spatial variation in these household and individual level factors is likely to explain part of the regional variation in rates of food security and insecurity.

In the next section, we describe a spatial model designed to investigate this variation among Indigenous people in New South Wales. This model combines both geographical and household level data to produce local estimates of Indigenous food security for the first time in Australia. In doing so, it aims to address some of the gaps in the literature identified above.

Methods

We employ a small-area estimation methodology to predict rates of food security and insecurity at the Statistical Area 2 (SA2) level. Such a modelling approach can only be as good as the data that it relies on. In our case, we draw primarily from the full 2021 Census of Population and Housing microdata and the National Aboriginal and Torres Strait Islander Health Survey (NATSIHS) 2018-19. We also employ a range of area-level covariates to draw in additional spatial information on factors influencing food security at the local level.

Data

The NATSIHS 2018-19 consists of a nationally representative sample of 10,579 Aboriginal and Torres Strait Islander people of all ages living in private dwellings. Individual samples were randomly selected through a multi-stage sampling process. In non-remote areas, up to two adults (aged 18 years and over) and two children (0-17 years of age) were selected. In remote areas, up to one adult (aged 18 and over) and one child (0-17 years of age) were selected. The survey provides a representative sample for all states/territories including New South Wales and remoteness areas. Additional information about its sampling design is available elsewhere (ABS, 2019).

The NATSIHS 2018-19 does provides representative sample of Aboriginal and Torres Strait Islander households, and includes information on a wide range of topics including food security. Information on food insecurity is collected through affirmative responses to the following questions:

- *Did you or someone in the household run out of food over the previous 12 months and could not afford to buy more?*
- *Did you or someone in the household go without food when ran out of food?*

The NATSIHS 2018-19 provides information on an array of household characteristics identified in our literature review as predictors of food insecurity, including but not limited to: equivalised household income, financial security, household composition, housing tenure, household size and crowding, and facilities for food preparation. Table 1 provides a list of survey variables used in this study.

Data for this predictive model were also sourced from Census 2021, where full counts of dwellings, families and persons were available through the MADIP (Multi-Agency Data Integration Project), a data integration environment that provides highly secure access to sensitive data. We accessed the full Census microdata, but did not undertake data linkage. Information on all relevant predictors of food security was available for a total of 128,316 Indigenous households within the census in NSW. Only household characteristics available and defined the same way as in the NATSIHS 2018-19 were used (see Table 1).

Additional data was extracted from geospatial and administrative records then converted to the Statistical Area 2 (SA2) level. These included:

- Average fuel prices over the last four financial years.
- Wholesale price of electricity.
- Total grocery outlets including their location and type.
- Distance from Indigenous populations to these outlets.
- Disaster vulnerability as measured by government declarations.
- Proportion of the Indigenous population receiving a Centrelink payment.

- Index of relative socioeconomic advantage and disadvantage, all measured at the Statistical Area Level 2 (SA2).

We could not identify suitable datasets to measure some Indigenous-specific protective factors associated with food security that were identified in the literature review, specifically access to customary provisioning and kin-based and community-based networks of sharing and support.

Table 1 Variables used for modelling

Description	Measurement
<i>Variables sourced from NATSIHS 2018-19 only</i>	
<i>Outcome variables</i>	
Ran out of food in the last 12 months and couldn't afford to buy more	1 if yes, 0 otherwise
Went without food when ran out of food	1 if yes, 0 if didn't go without food when ran out of food, or if didn't ran out of food in the past 12 month.
<i>Predictor variables</i>	
Food preparation facilities: Whether the house has working facilities for preparing food e.g. refrigerator, stove, oven and kitchen sinks	1 if yes, 0 otherwise
Financial stress in the HH: Whether household members could raise \$2,000 during an emergency	1 if they could; 2 if they couldn't; 3 if not known whether they could or couldn't.
Daily smokers in the HH: Whether any daily smoker lives in the household	1 if yes, 0 otherwise
HH income - wage: Whether the main source of household income is a wage	1 if yes, 0 otherwise
HH income - welfare: Whether the main source of household income is government payment/welfare	1 if yes, 0 otherwise
<i>Variables sourced from NATSIHS 2018-19 and Census 2021</i>	
Log of HH income: Log of equivalised total weekly household income	Logarithm of the average value of income categories
Single parent family HH: Whether there is a single parent family in the household	1 if yes, 0 otherwise
Persons aged 0-14: Number of household members aged 0-14 years	counts of people
Persons over 14: Number of household members aged over 14 years	counts of people
Seniors in the HH: Whether someone aged 65 years and over lives in the household	1 if yes, 0 otherwise

Description	Measurement
Housing suitability: Whether there is crowding in the dwelling	1 if neither spare bedrooms present nor extra bedrooms needed; 2 if spare bedrooms present; 3 if extra bedrooms needed
Housing tenure: Whether a dwelling is owned, being purchased, or rented	1 if owned outright; 2 if owned with a mortgage; 3 if rented; 4 if other (such as if occupied rent free or under life tenure scheme)
Mortgage affordability: proportion of Indigenous households paying over 30% of their income for mortgage	As a fraction of total households at the SA2 level
Rent affordability: proportion of Indigenous households paying over 30% of their income for rent	As a fraction of total households at the SA2 level
<i>Variables sourced from NATSIHS 2018-19 and Census 2016</i>	
Geographic remoteness	1 if major cities; 2 if inner regional areas; 3 if outer regional areas; 4 if remote areas; 5 if very remote areas
Index of relative socio-economic advantage and disadvantage (IRSAD) ¹	Standardised scores at the SA2 level
<i>Variables sourced from administrative records and geospatial data</i>	
Log of average price of petrol (E10 and U91) over the period 2018-2021	Logarithm of average price of fuel at the SA2 level
Wholesale price of electricity	Cents per kwh calculated at SA2 the level
Disaster vulnerability	Number of times an SA2 has been declared an 'ongoing' disaster zone across 2018, 2019, 2021 and 2022 financial years. (Spatially converted from LGA declarations).
Social security recipients	Percentage of Indigenous persons aged 16-64 years receiving Centrelink payment ² at the SA2 level
Distance to the nearest large supermarket (e.g. Woolworths, Coles, ALDI)	Logarithm of average distance in km within an SA2
Distance to the nearest grocery outlet (any)	Logarithm of average distance in km within an SA2

Modelling household food insecurity

For the sake of parametrisation, suppose the relationship between food security status of a household and its determinants can be written as:

¹ This index summarises information about economic and social conditions (such as income and occupational skill level) of people and households within an area on a scoring scale. A low score shows greater disadvantage and a high score shows greater advantage (ABS, 2018).

² This includes working-age payments such as ABSTUDY living allowance; Austudy; Carer payment; Youth allowance and JobSeeker payment, and excludes payments such as Age pension and concession cards.

$$y_h = F(x_{1h}, x_{2h}, \dots, x_{nh}) \quad (1)$$

where, $F(\cdot)$ is an unknown function, y_h is food insecurity status of household h ; and $x_{1h}, x_{2h}, x_{3h}, \dots, x_{nh}$ are determinants of food security status of household h . Elements of x_h would include all relevant household-level characteristics (such as income and socioeconomic status) but also a range of area-specific characteristics (such as availability of food outlets and vulnerability to natural disaster).

Estimating Eq. (1) requires identifying the specific functional form for $F(\cdot)$, which depends, among other things, on the data-generating process that defines y_h . For this study, data on food security status of Indigenous households were derived from responses to the two survey questions outlined in the previous section. As such, a household is considered moderately food insecure if the response to the first question is 'yes' and severely food insecure if the response to the second question is 'yes'. Without loss of generality, the value of the food insecurity variable can be defined as:

$$y_h = \begin{cases} 1 & \text{if the household is food insecure} \\ 0 & \text{otherwise} \end{cases}$$

Under this data-generating process: $y_h \sim \text{Bernoulli}(p_h)$. Therefore, the function specified in Eq. (1) can be written in an estimable form as:

$$p_h = \text{Pr}(y_h = 1 | x_h) = F(x_h' \beta) \quad (2)$$

where, $F(\cdot)$ is a cumulative distribution function (*cdf*), p_h is the probability of a household being food insecure; x_h is a vector of predictors of the propensity of a household being food insecure, which could include some or all of the variables listed in Table 1; and β is a vector of coefficients corresponding to x_h .

The most common approach to estimate parameters in equations such as Eq. (2) is to use either a logit or a probit regression model. In this study, we use a logit model of household food insecurity specified as:

$$\text{logit}(p_h) = \log\left(\frac{p_h}{1-p_h}\right) = x_h' \beta \quad (3)$$

A key issue worth pointing out regarding applying Eq. (3) to our data is clustering of households. If we wish to assume that our data were generated through a simple random sampling process and x_h consists of all relevant factors that underlie household food insecurity, we can expect robust estimates from the logit model. However, sample households in NATSIHS 2018-19 were selected through a multi-stage cluster sampling process. Generally, cluster sampling results in larger sample-to-sample variability than simple random sampling and failing to account for such variability can understate standard errors. Further, due to the multi-stage random process, it is likely that households have an unequal probability of being included in the sample, and omitting sampling weights from the analysis may bias parameter estimates (StataCorp, 2017). To adjust point estimates and standard errors for the complex survey design in NATSIHS 2018-19, we use jackknife variance estimators with replicate survey weights.

Moreover, since NATSIHS households are nested within clusters, which are used as primary sampling units,³ those households within the same cluster tend to share similar characteristics and become interdependent. In other words, households residing within close geographic proximity may have common attributes that make

³ NATSIHS 2018-19 used different primary sampling units in its design, discrete Indigenous communities for community samples-mainly in remote areas and mesh blocks for non-community samples-mainly in non-remote areas.

them particularly more or less food secure. Similarly, households that live in a particular area could experience food insecurity due to conditions specific to that area. In a more complex situation, the same predicting factor (such as household income) may have differential impacts on food security in different areas. To allow for the clustering of households within area a and the interdependence between them, we used an alternative specification of the logit model as follows:

$$\text{logit}(p_{ha}) = x'_{ha}\beta + \xi_a \quad (4)$$

This is a multilevel mixed-effects logistic model with a random location effect ξ_a ; where, $\xi_a \sim N(0, \sigma_\xi^2)$. In the case of $\xi_a = 0$; Eq. (4) will be reduced to Eq. (3). We specify random location effects at the Statistical Area 2 (SA2) level for which data is available.

Predicting food insecurity at the SA2 level

As indicated above, the NATSIHS 2018-19 provides a representative sample for the Aboriginal and Torres Strait Islander population in New South Wales (NSW). Using the food security data in this NATSIHS survey, we can, therefore, directly estimate the prevalence of food insecurity (such as the per cent of food insecure households or the per cent of individuals who live in food insecure households) for the Aboriginal and Torres Strait Islander population in NSW. However, the NATSIHS was not designed to provide estimates for sub-areas within NSW, such as SA2s (Statistical Area Level 2s). For some areas, samples are either too small or non-existent to make accurate statistical inferences about food insecurity. Only 158 of the 642 SA2s in NSW were included in NATSIHS 2018-19, and over 80% of them had less than 10 sample households.

Generally, the approach to address the lack of observations in target small areas is to borrow auxiliary information from other data sources to increase the effective number of observations needed for estimation in the areas of interest (see, the literature review on small area estimation for more information). Accordingly, we use a model-based small area estimation technique to fill data gaps and to estimate the proportion of food-insecure households at an SA2 level in NSW. SA2s were selected as the geographical unit of analysis as they are the smallest geographic units for which food security data are available.

We combine parameter estimates obtained from Eq. (3) with Census 2021 data using the following procedures. First, the logit model presented in Eq. (4) was fitted to the NATSIHS data to obtain coefficient estimates and linear predictions.⁴ Second, the estimates were applied to the census population data to generate 100 simulated (out-of-sample) vectors of household food insecurity status. Third, an SA2-level food insecurity rate (a percentage of food insecure households) was calculated with each population vector, which were then averaged over 100 simulations to produce a point estimate (along with a standard error and confidence interval) for each SA2.

Results

The prevalence of Indigenous food insecurity by remoteness in NSW

Figure 1 depicts the rate of household food insecurity in NSW based on responses to the above two NATSIHS survey questions. Sampling weights have been accounted for so that the estimates would be representative of the Indigenous household population in NSW. Across NSW, 23% of Aboriginal and Torres Strait Islander households have had a household member who ran out of food and couldn't afford to buy more food over the 12

⁴ Where the area-level residual was drawn from normal distribution with mean zero and variance V , estimated variance component from the linear mixed-model.

months prior to the survey. Households with members who went without food then ran out of food, account for 10% of total households.

Disaggregating the results by geographic remoteness reveals a complex picture. In terms of running out of food, remote areas of Australia have the lowest percentage, while very remote areas have the highest percentage. The percentage is similar for major cities and outer regional areas and slightly higher for inner regional areas (by two percentage points).

In terms of going without food, remote areas still have the lowest percentage of households experiencing food insecurity. This is followed by very remote areas, whose residents are, by comparison, very likely to run out of money to buy food but are relatively less likely to go hungry. Outer regional areas, followed by inner regional areas, have the next highest percentage of households going without food.

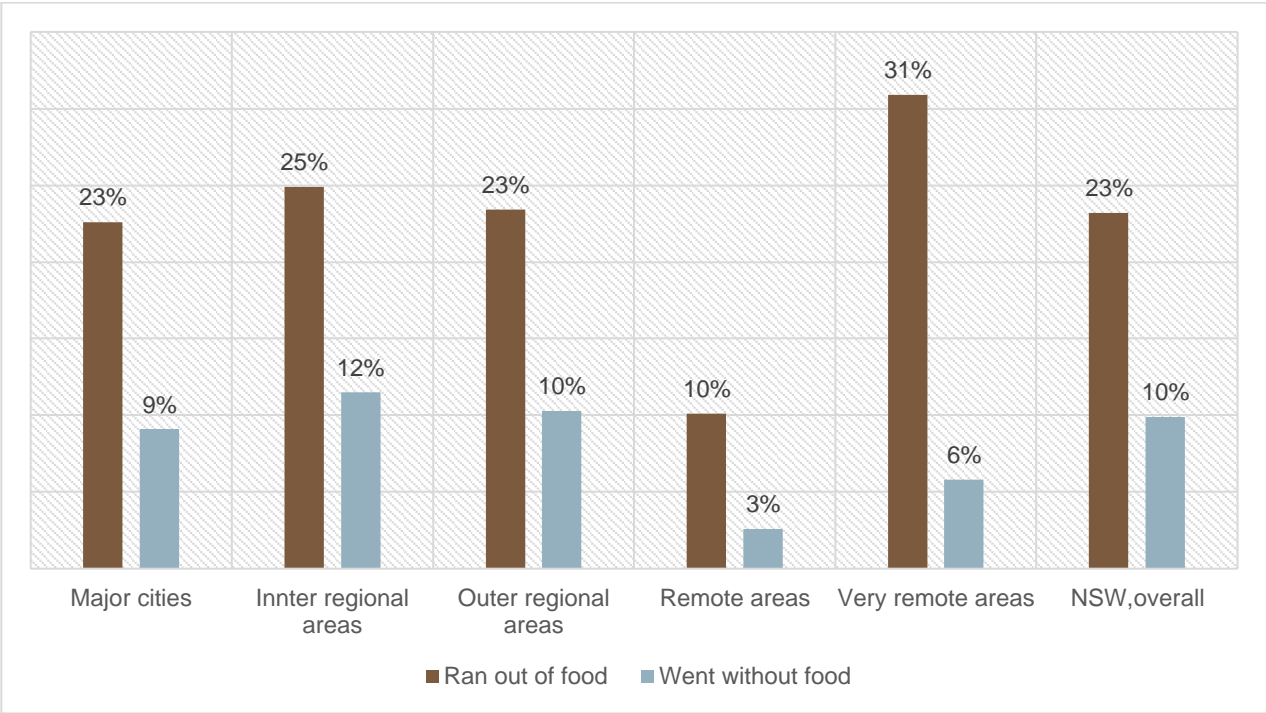


Figure 1 Food insecurity among Indigenous households in New South Wales, by geographical remoteness, 2018–19

Source: Authors' computation from ABS's TableBuilder-NATSIHS 2018-19.

Predictors of household food security

This subsection provides a brief presentation of the results obtained from logistic regressions. Three sets of specifications were fitted for each measure of food insecurity.

Specification 1 includes geographic remoteness and household-level data available in NATSIHS 2018-19 but not in Census 2021. This is the preferred model to predict household-level food insecurity since it includes a range of demographic and socioeconomic variables identified in the literature as key determinants of food (in) security. However, it could not be used to estimate area-level food insecurity prevalence in small geographical areas since some of the key variables (such as financial stress, availability of cooking facilities and main source of income) were not available in Census 2021.

Specification 2 is a more parsimonious model that removes some variables present in Specification 1. It includes geographic remoteness and only household-level data common to both NATSIHS 2018-19 and Census 2021. This was the specification chosen for small-area estimation. Regression equations from this specification are presented in Appendix A.

Specification 3 builds on Specification 2 but adds the geospatial and administrative datasets by SA2 as presented in Table 1. Regression results from this specification are reported in Appendix B, Table B1. The specification was fitted to account for area-level effects on household food (in) security and to improve upon the predictive power of the logit model with greater precision. However, a series of Wald tests showed that the coefficients on the area-level characteristics were jointly insignificant, and so this model was not used to make small-area estimations.

The parameters presented in Tables 2 and 3 are marginal effects (m.e) and 95% Confidence Intervals (CIs). The outcome variable takes the values [0, 1] in the logit model, where 1 represents being food insecure and 0 represents being food secure. Therefore, positive marginal effects represent risk factors whereas negative marginal effects represent protective factors. The interpretation of marginal effects depends on the level of food insecurity being predicted. Marginal effects measure changes in the outcome variable (the probability of households being food insecure) associated with a 1% change in log variables (such as, *Log of HH income*), a unit change in count variables (such as, *Persons aged 0 – 14 years*) and a category change in categorical variables (such as, *Remoteness*). In looking at Column 1 of Table 2, for example, we note that households' probability of being food insecure:

- Decreases by 1.4 percent points when equivalised total weekly household income increases by 1%.
- Increases by 6.5 percentage points when the number of children aged 0-14 increases by one.
- Is lowered by 14 percentage point in remote areas than in major cities.

Bold cells show that the underlying marginal effects are statistically significant. Those bold cells with confidence interval values that do not include zero are statistically significant at the 5% significance level whereas the bold cells whose confidence interval values include zero are only statistically significant at the 10% significance level.

It is important to note that the presence of a statistically significant relationship between food insecurity and the predictor variables included in the model does not necessarily imply causality. For example, if we see the relationship between Log of HH income and food insecurity in Specification 2, it may be that increases in household income increases access to food, or that food insecurity leads to poor health which in turn may lead to reduced income, or that both income and food insecurity are a result of structural disadvantage. Similarly, readers should not interpret non-statistically significant relationships between food insecurity and the predictor variables as evidence of absence of relationship. For example, some of the estimated marginal effects (see, for instance, those associated with *Housing suitability – Extra bedrooms needed* and *Housing tenure – Rented*) are large in magnitude (but statistically insignificant). While such estimates may reflect relationships that do exist between food security and the underlined regression variables, they could be detected with low precision for various reasons, including study design, survey instruments and sample sizes.

Table 2 presents regression results associated with running out of food. In looking at Specification 1, the marginal effect of equivalised weekly household income is statistically insignificant. This is not consistent with theories and the empirical evidence outlined in the literature review. This is perhaps because the logit model includes a measure of financial stress, whether household members could raise \$2,000 during an emergency. We note that households whose members could not raise \$2,000 during an emergency are 22.2 percentage points more likely to run out of food. It is worth noting that the food insecurity variable indicates 'whether

households ran out of food in the past 12 months and couldn't afford to buy more'. That means households who run out of food may be able to acquire food if they could call on their networks for support.

A strong statistical correlation between income and households' ability to raise \$2,000 is another possible reason for income's marginal effect being small and statistically significant. Bivariate analysis shows that a one per cent increase in household income is associated with a 29-percentage point in the probability of a household member being able to raise \$2,000 during an emergency. The strong statistical correlation is also evidenced by the results in Specifications 2 and 3, where the financial stress variable is excluded from the logit model and income has had a statistically significant effect on food insecurity. A one per cent increase in equivalised weekly household income is associated with a decrease in the probability of being food insecure by 8.3 percentage points (Specification 2) and 7.5 percentage points (Specification 3-Table B1).

An increase in household size appears to be positively associated with an increased risk of food insecurity. However, a closer look at the age composition of household members reveals an interesting picture. An increase in the number of young household members poses a larger and statistically significant risk to household food security. The presence of an additional person (aged 0-14 years) in the household is associated with a 6.5-percentage point increase in the probability of the household being food insecure. On the other hand, an increase in the number of household members aged 14 years and over is only associated with a 2.4 percentage point increase in food insecurity, an effect not statistically significant at the 10% significance level.

There appears to be no statistically significant association between housing crowding and food insecurity. But in terms of signs of statistical association, households with spare bedrooms are less likely to be food insecure whereas those who need an extra bedroom are more likely to be food insecure than households with neither spare bedrooms nor a shortage of bedrooms. Despite the low precision, the marginal effect associated with being crowded is too large to ignore (7.5 percentage points).

The effects of housing tenure on food security are too large to ignore despite being statistically insignificant. Compared with households who live in their dwelling owned outright, those who live in a dwelling owned with a mortgage are 5.9 percentage points more likely to be food insecure and those who live in a rental property are 12.4 percentage points more likely to be food insecure.

Another household characteristic found to have a considerable association with food insecurity is household composition. Group family (or non-family) households are 25.8 percentage points more likely to be food insecure than single-parent family households. This is by far the largest marginal effect estimated in the model. Single-parent family households are also more likely (by about five percentage points) to experience food insecurity. On the other hand, households with members aged 65 years and over are less likely (by 8.3 percentage points) to be food insecure. However, both marginal effects have large standard errors, making them statistically insignificant.

The presence of functioning food preparation facilities protects against food insecurity, with a 10.8-percentage point decrease in the likelihood of being food insecure. There appears to be a substantial association between the main source of household income and running out of food, with households whose main earnings are from wages and salary being less likely to be food insecure while those households who mainly get their income from government support are more likely to be food insecure.

The probability of being food insecure also tends to vary across geographic remoteness. For instance, the probability of being food insecure is lower by 9.7 percentage points in outer regional areas, by 14 percentage points in remote areas and by 7.8 percentage points in very remote areas when compared to major cities. The result for very remote areas appears to be at odds with survey estimates, presented in Figure 1, where the prevalence of running out of food is highest in very remote areas. The regression result suggests that once

differences in household demography and socioeconomic status between households in major cities and very remote areas are accounted for, the probability of being food insecure is lower in remote areas.

The results in Specifications 2 and 3 are of a similar order of magnitude (e.g. the marginal effects associated with household income, number of persons aged 0-14 years, group family households and single-parent families). It is worth noting changes in the estimated marginal effects of household income between Specification 1 and Specifications 2 and 3. In Specification 1, a one per cent increase in equivalised weekly household income does not affect household food security. However, in Specifications 2 and 3, it is associated with a decrease in household food insecurity by about eight percentage points. As mentioned previously, this is perhaps because of the exclusion of the variable 'financial stress' from the latter two specifications. It is also worth pointing out that the estimated effect of having a single-parent family in the household is statistically significant and larger in Specification 2 and Specification 3 (Table B1) (12 and 14 percentage points, respectively).

Table 2 Factors associated with running out of food in a 12-month period for Indigenous households in NSW

Variable	Specification 1			Specification 2		
	m.e	95% CI		m.e	95% CI	
Log of HH income	-0.014	[-0.094	0.065]	-0.075	[-0.139	-0.011]
Persons aged 0-14 years	0.065	[0.026	0.105]	0.066	[0.028	0.102]
Persons over 14 years	0.024	[-0.039	0.087]	0.021	[-0.038	0.081]
Housing suitability						
Spare bedrooms present	-0.020	[-0.106	0.064]	-0.037	[-0.140	0.066]
Extra bedrooms needed	0.075	[-0.268	0.418]	0.085	[-0.256	0.426]
Housing tenure						
Owned with a mortgage	0.059	[-0.267	0.384]	0.073	[-0.174	0.320]
Rented	0.124	[-0.179	0.426]	0.185	[-0.041	0.410]
Other	0.005	[-0.339	0.035]	0.030	[-0.242	0.302]
Household composition						
Multiple family HHs	-0.005	[-0.270	0.260]	-0.010	[-0.270	0.250]
Group family HHs	0.258	[0.097	0.419]	0.284	[0.126	0.442]
Single-parent family in the HH	0.048	[-0.067	0.164]	0.119	[-0.008	0.246]
Seniors present in the HH	-0.083	[-0.222	0.056]	-0.060	[-0.206	0.087]
Food preparation facilities	-0.108	[-0.307	0.091]			
Financial stress						
Couldn't raise \$2,000	0.222	[0.106	0.338]			
Not known	-0.037	[-0.322	0.246]			
Daily smokers in the HH	0.022	[-0.101	0.058]			
HH income- wage	-0.067	[-0.166	0.032]			
HH income-welfare	-0.049	[-0.120	0.101]			
Remoteness						
Inner regional areas	-0.036	[-0.122	0.049]	-0.032	[-0.136	0.071]
Outer regional areas	-0.097	[-0.196	0.001]	-0.077	[-0.188	0.034]
Remote areas	-0.140	[-0.255	-0.023]	-0.136	[-0.249	-0.025]
Very remote areas	-0.078	[-0.187	0.031]	-0.029	[-0.146	0.088]
Number of observations		864			864	

Table 3 presents regression outcomes concerning going without food. In Specification 1, household income is not significantly correlated with food insecurity. This is because households under financial stress (incapable of obtaining \$2,000 in emergencies) exhibit a 13.4 percentage point increase in the prevalence of food insecurity.

Household size emerges as a primary determinant. Analysing age group effects reveals that an additional household member aged 0-14 years corresponds to a nine-percentage point increase in the likelihood of going without food. The influence of older household members is relatively minor—a three-percentage point increase—and statistically insignificant. Examining the estimated marginal effects' signs, households with surplus bedrooms display higher food insecurity, while those requiring extra bedrooms exhibit lower food

insecurity. Compared with single family households, group households exhibit a 22.7 percentage point increase in food going without food. The estimated impacts of cooking facility availability, single-parent family presence, and senior household member presence are negligible and statistically insignificant.

Table 3 Factors associated with going without food in a 12-month period for Indigenous households in NSW

Variable	Specification 1			Specification 2		
	m.e	95% CI		m.e	95% CI	
Log of HH income	-0.013	[-0.052	0.02]7	-0.033	[-0.063	-0.003]
Persons aged 0-14 years	0.089	[0.063	0.144]	0.085	[0.063	0.107]
Persons over 14 years	0.032	[-0.008	0.073]	0.030	[-0.012	0.071]
Housing suitability						
Spare bedrooms present	0.036	[-0.029	0.101]	0.021	[-0.049	0.091]
Extra bedrooms needed	-0.069	[-0.156	0.017]	-0.068	[-0.157	0.021]
Housing tenure						
Owned with a mortgage	-0.054	[-0.156	0.049]	-0.010	[-0.095	0.075]
Rented	-0.037	[-0.134	0.060]	0.030	[-0.050	0.112]
Other	-0.124	[-0.216	-0.032]	-0.062	[-0.136	0.011]
Household composition						
Multiple family HHs	0.010	[-0.096	0.116]	0.040	[-0.088	0.168]
Group family HHs	0.227	[0.136	0.318]	0.253	[0.167	0.340]
Single-parent family in the HH	0.015	[-0.084	0.054]	0.024	[-0.050	0.010]
Seniors present in the HH	-0.022	[-0.105	0.060]	-0.007	[-0.094	0.081]
Food preparation facilities	-0.009	[-0.148	0.129]			
Financial stress						
Couldn't raise \$2,000	0.127	[0.054	0.200]			
Not known	0.017	[-0.017	0.053]			
Daily smokers in the HH	0.002	[-0.061	0.066]			
HH income- wage	-0.026	[-0.093	0.041]			
HH income-welfare	0.035	[-0.056	0.126]			
Remoteness						
Inner regional areas	-0.016	[-0.079	0.046]	-0.026	[-0.100	0.046]
Outer regional areas	-0.059	[-0.122	0.004]	-0.044	[-0.121	0.033]
Remote areas	-0.109	[-0.179	-0.038]	-0.110	[-0.180	-0.040]
Very remote areas	-0.069	[-0.131	-0.007]	-0.056	[-0.123	0.010]
Number of observations		864			864	

The probability of food insecurity diminishes in households with a mortgaged home (by 5.4 percentage points), rental properties (by 3.7 percentage points), and alternative housing tenures (e.g., rent-free occupancy or life tenure schemes) (by 12.4 percentage points). However, only the "other" tenure type effect is statistically significant, suggesting those with unconventional or housing types unable to be categorised are at greater risk of food insecurity.

Compared to major cities, the probability of going without food declines by 5.9 percentage points in outer regional areas, 10.9 percentage points in remote areas, and 6.9 percentage points in extremely remote areas. In other words, those in major cities and inner regional areas were more likely to have gone without food than those in remote and outer regional areas.

Specifications 2 and 3 (Table B1) estimating the prevalence of going without food, display estimates of a similar magnitude as the previous model estimating running out of food. For instance, observe the marginal effects associated with 'log of HH income' and 'persons aged 0-14 years' variables. In both specifications, a one per cent increase in equivalised weekly household income corresponds to approximately a three-percentage point decline, while an increase in household size by one person (aged 0-14 years) correlates with a nine-percentage point elevation in food insecurity likelihood.

The spatial distribution of Indigenous food insecurity in NSW

This subsection presents estimates of food insecurity prevalence at the SA2 level. Based on Census 2021, while there are 642 SA2s in NSW, Indigenous households live in 604 of them, with the number of households ranging from less than 10 to 1265, the average being 216. To reduce risks of disclosure and statistical imprecision, we excluded SA2s with fewer than 10 Indigenous households and estimated the prevalence of food insecurity for 595 SA2s.

Table 4 provides a statistical summary of the food insecurity estimates for SA2s (full area-level estimates are presented in Appendix C). The first two rows provide estimates associated with running out of food. The estimates for the 595 SA2s range between 5.4% and 48.6%, with an average of 22% and a standard deviation of 7.1%. The associated standard errors are reasonably small, ranging from 0.1 % to 1.3%, averaging 0.4%. The final two rows of the table show estimates associated with going without food. The estimates range from 1% to 32%, and average 10.2% with a standard deviation of 5%. Their standard errors are very low, ranging between 0.1% and 1.2%, averaging 0.3%. Overall, it appears that spatial variability is greater among estimates of running out of food than estimates of going without food. Comparison of model-based estimates with those directly estimated from the NATSIHS 2018–19 Survey are presented in Table C1 in the appendices.

Table 4 Summary of model-based estimates of the prevalence of Indigenous food insecurity in SA2s in NSW

Estimates	Mean	Standard deviation	Minimum	Maximum
<i>Running out of food</i>				
Prevalence rate	22.0%	7.1%	5.4%	48.6%
Standard error	0.4%	0.2%	0.1%	1.3%
<i>Going without food</i>				
Prevalence rate	10.2%	5.0%	1.1%	32.0%
Standard error	0.3%	0.2%	0.1%	1.2%

The model-based estimates show the percentage of Indigenous households that run out of food each year in SA2s across New South Wales are displayed Figure 2. This map shows limited spatial patterns on the prevalence of food insecurity. The most obvious concentrations of food insecurity according to this measure are in the far west of NSW, as well as in some regional towns like Grafton, Armidale, Eden and Orange. Areas with

the most food security are estimated to be in rural areas such as the Southern Highlands and Monaro. However, due to the scale of this map, estimates within large urban areas like Sydney and the Central Coast are not visible. For this reason, these have been displayed in separate maps.

Figure 3 shows the distribution of model-based estimates of households running out of food in Sydney. It is evident from Figure 3 that, according to our model, food insecurity is more prevalent in Sydney than in many regional areas visible in Figure 2. Particular hotspots of food insecurity are evident across large parts of Sydney, including the areas around Mount Druitt, Penrith, Paramatta, Liverpool, Bankstown, Fairfield, Redfern, Macquarie Park and La Perouse. Areas of relative food security are also evident, particularly on Sydney's North Shore.

Figure 4 shows that there are pockets of high food insecurity adjacent to areas of relative food security on NSW's Central Coast. Areas with a high prevalence of predicted Indigenous food insecurity include Newcastle, Wyong, Raymond Terrace, Woy Woy and Gosford. Adjacent areas like Kincumber - Picketts Valley were estimated to have lower levels of food insecurity. Figure 5 shows similar patterns in the Illawarra region. Inner Wollongong and Port Kembla are estimated to be relatively food insecure, while Indigenous households in Albion Park and Kiama are less likely to run out of food each year.

These maps have shown model-based estimates of the proportion of Indigenous households who run out of food each year. The next series of maps displays model-based estimates of the proportion of Indigenous households who went without food after running out, each year. The spatial patterns are considerably different.

When viewed state wide in Figure 6, the hotspots of insecurity of estimated food insecurity that are most evident are those in regional towns like Albury, Wagga Wagga, Queanbeyan, Tweed Heads, Murwulimbah, Grafton, Maitland, and the Eurobodalla Hinterland on the South Coast. Areas of relative security are evident in the south-west around Balranald and Hay, and in an arc from Condobolin through Nyngan to Walgett and Lightning Ridge, as well through large parts of the Hunter Valley and Monaro.

Figure 7 which focuses on Sydney shows a slightly different pattern to Figure 3. Large hotspots of food insecurity are still evident around Liverpool, Fairfield, Bankstown, Redfern, Blacktown and Mount Druitt. New hotspots also emerge around Castle Hill, Miranda and Collaroy. Areas of relative food security are largely unchanged.

On the Central Coast and Newcastle, the patterns of predicted food insecurity are relatively consistent between Figure 8 and Figure 4. Maitland emerges as a more important hotspot of insecurity when examining the propensity to go without food, while Newcastle, Wyong, Gosford and Woy Woy remain areas of concern. Patterns of food insecurity in the Illawarra also largely similar between Figure 9 and Figure 5, with Wollongong and Port Kembla being estimates to have the highest prevalence of Indigenous households going without food.

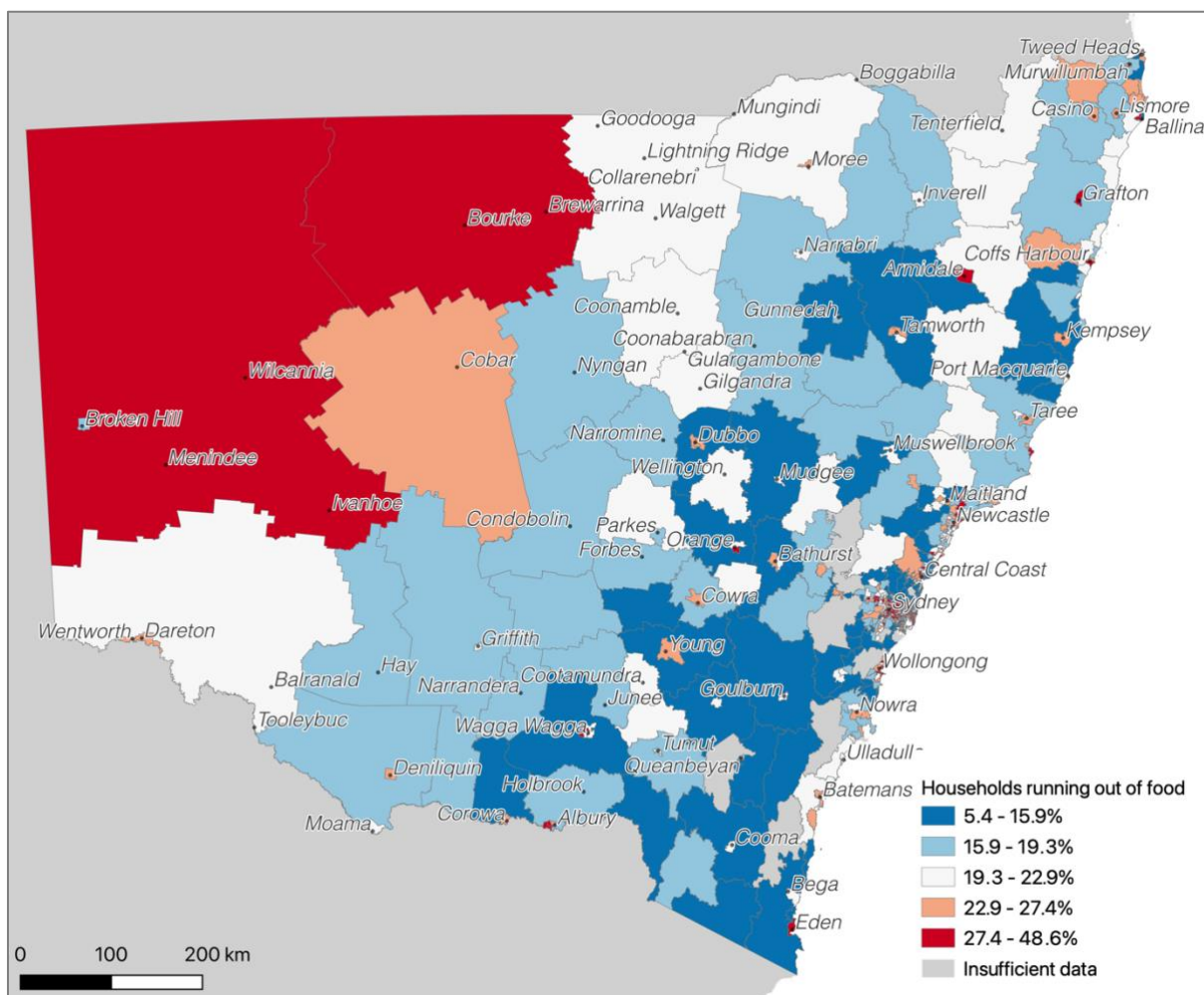


Figure 2 Model-based small area estimates of the percentage of Indigenous households that report running out of food each year, by SA2, New South Wales

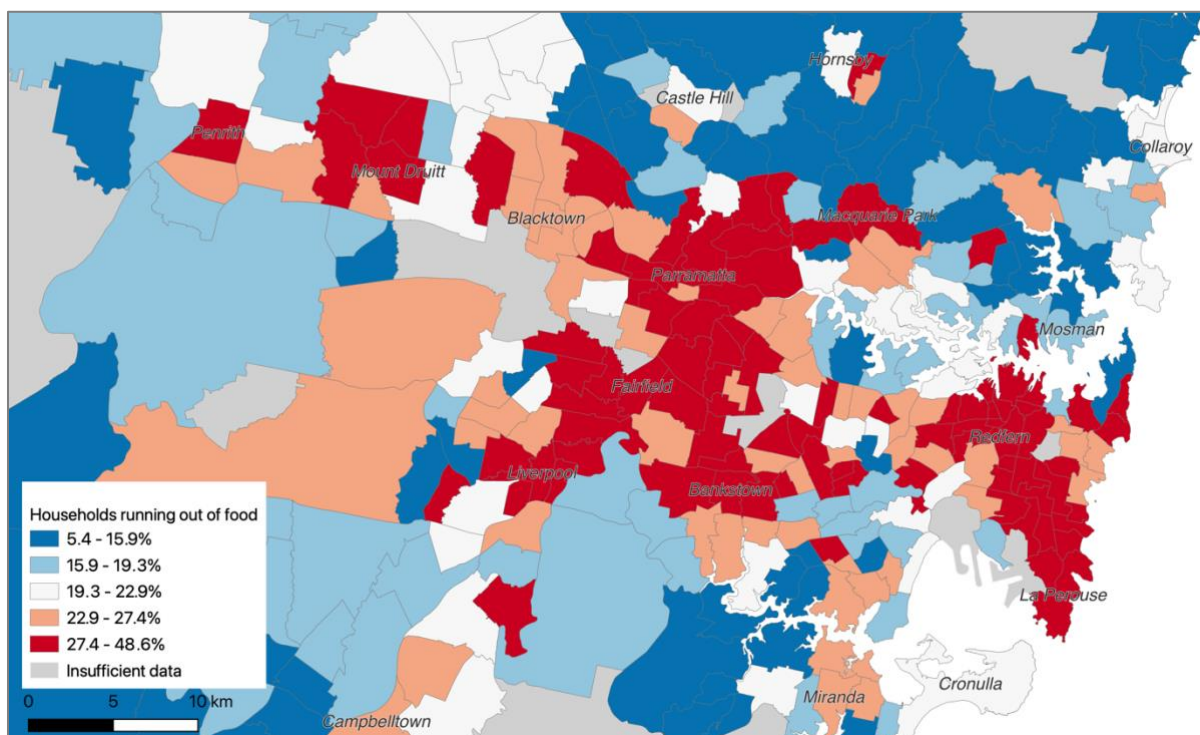


Figure 3 Model-based small area estimates of the percentage of Indigenous households that report running out of food each year, by SA2, Sydney

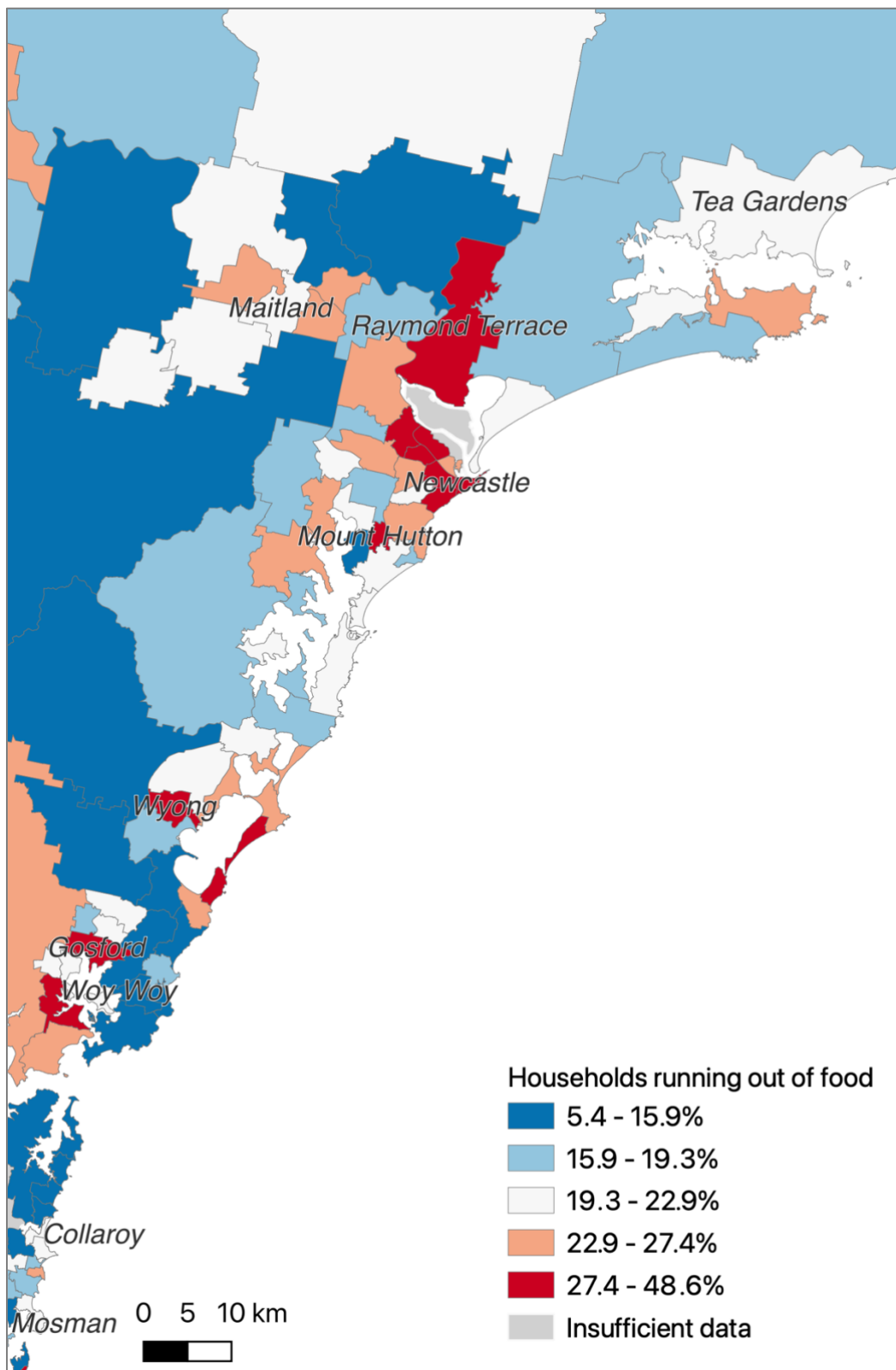


Figure 4 Model-based small area estimates of the percentage of Indigenous households that report running out of food each year, by SA2, Central Coast and Newcastle

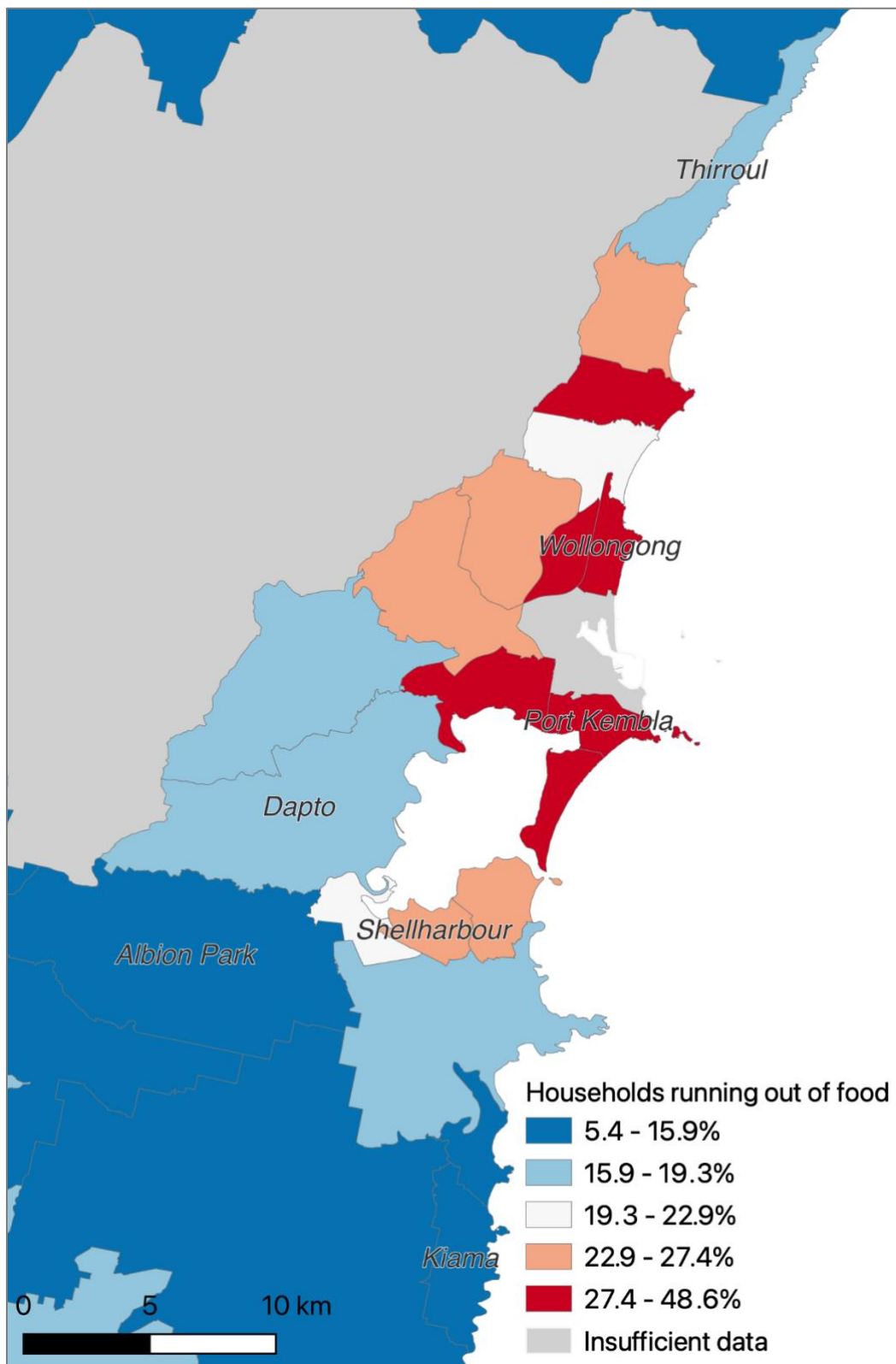


Figure 5 Model-based small area estimates of the percentage of Indigenous households that report running out of food each year, by SA2, Illawarra

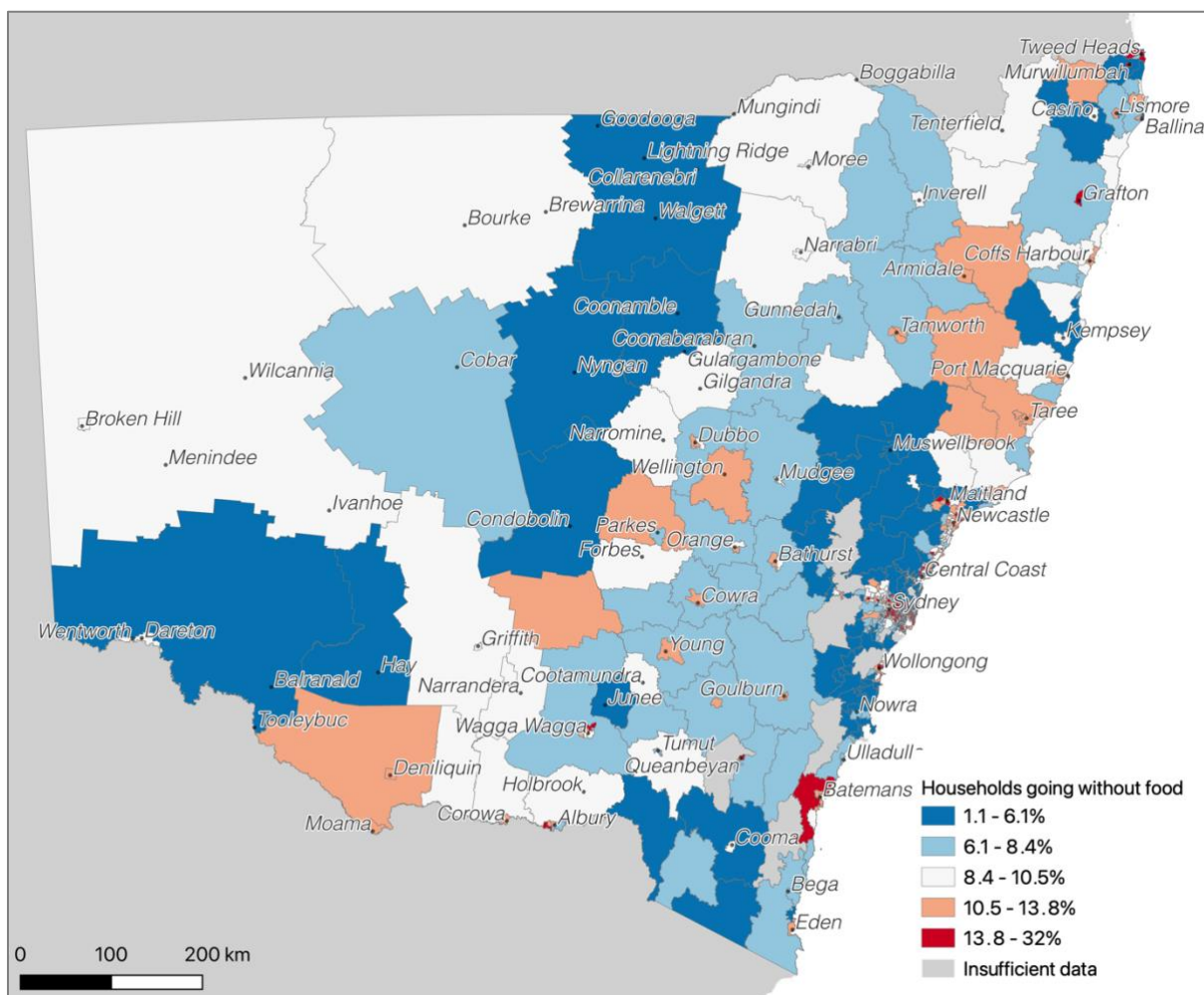


Figure 6 Model-based small area estimates of the percentage of Indigenous households that report going without food each year, by SA2, NSW

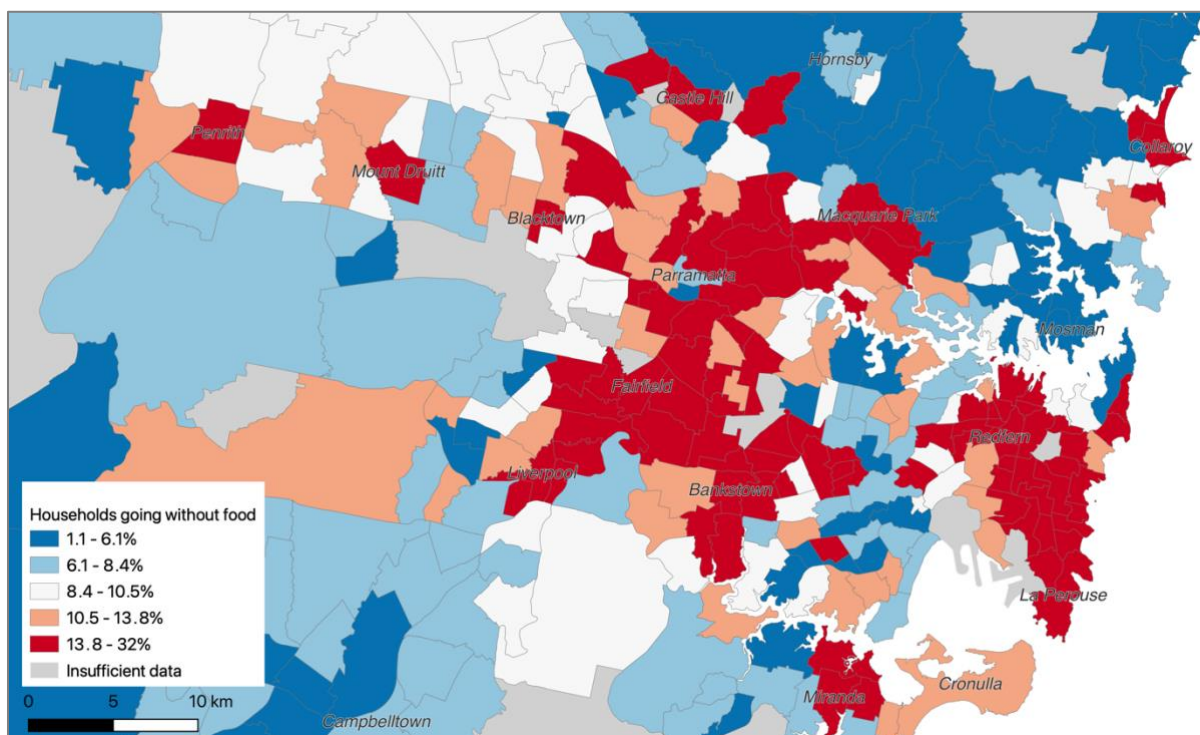


Figure 7 Model-based small area estimates of the percentage of Indigenous households that report going without food each year, by SA2, Sydney

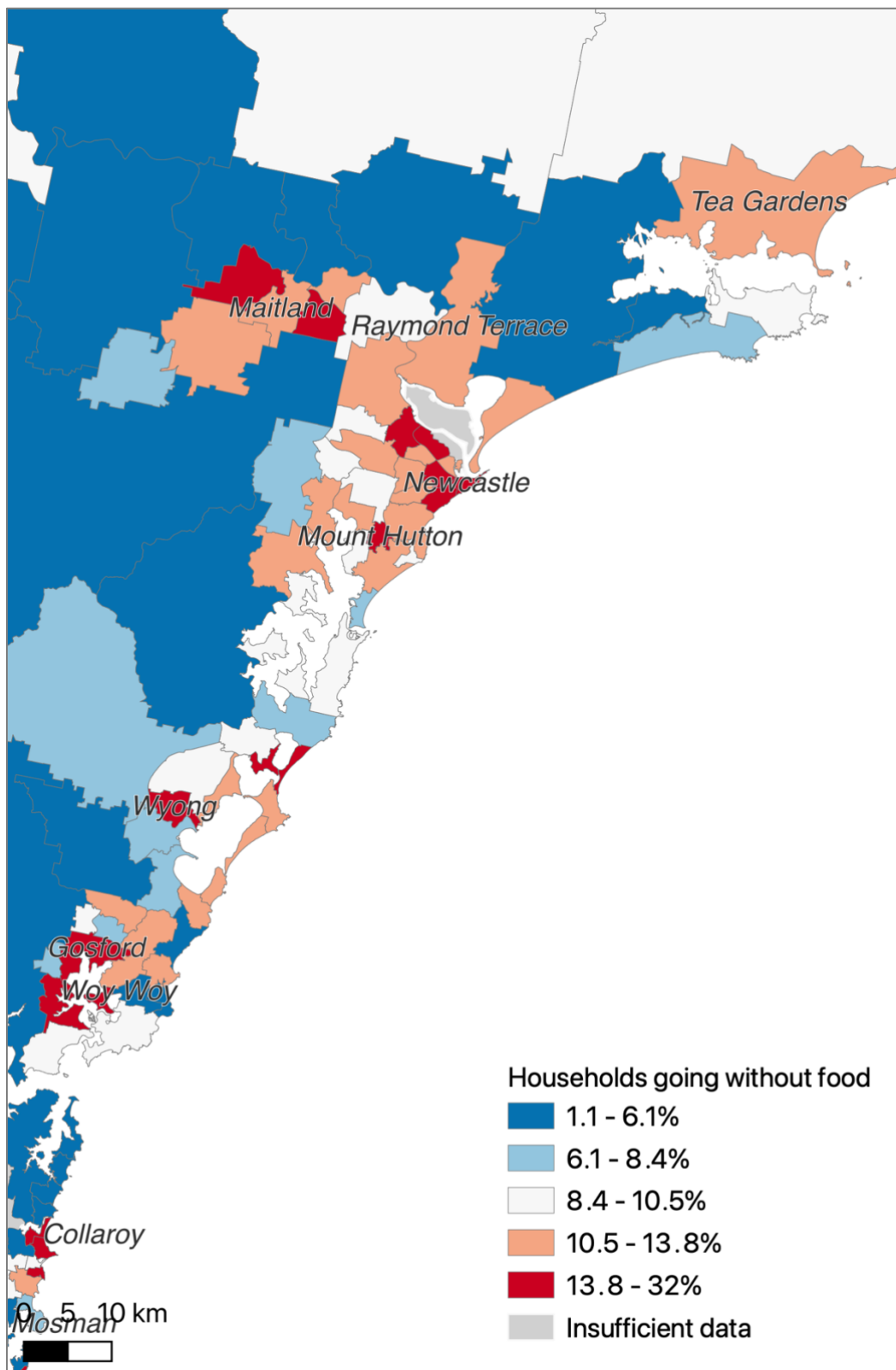


Figure 8 Model-based small area estimates of the percentage of Indigenous households that report going without food each year, by SA2, Central Coast and Newcastle

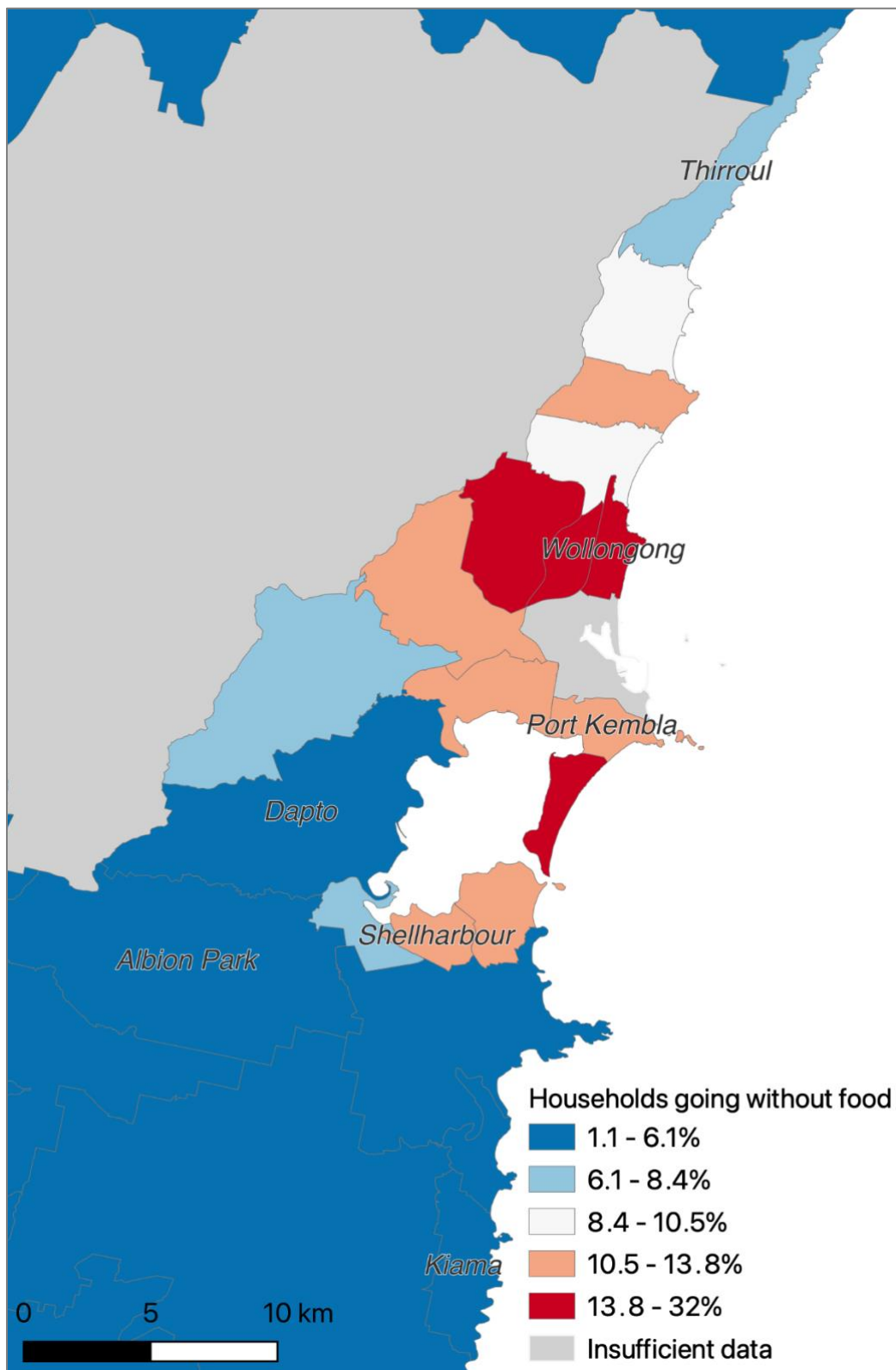


Figure 9 Model-based small area estimates of the percentage of Indigenous households that report going without food each year, by SA2, Illawarra

Concluding comments

The 2018-19 NATSIHS collected data on food security: whether someone in a household run out of food in the 12 months before the survey and couldn't afford to buy more; and whether someone in the household went without food when ran out of food. The survey provides a representative sample for NSW. Direct estimates show that, amongst Aboriginal and Torres Strait Islander households in NSW, about 23% have had a household member who ran out of food and couldn't afford more and about 10% have had a member who went without food when ran out of food. However, little was known about the factors that underlie food (in)security status of households and the spatial distribution of food insecurity prevalence.

Using model-based approaches, this study has addressed this by:

1. Identifying major predictors of household food insecurity.
2. Estimating the prevalence of food insecurity at the SA2 level.

Results from logistic regressions show that household food (in) security of Indigenous households in NSW is associated with:

- household income and financial stress,
- household size and composition,
- housing tenure,
- the presence of cooking facilities in the home, and
- remoteness.

Estimates of a logit model from NATSIHS 2018-19 data were applied to household-level census data to estimate the prevalence of food insecurity. Estimates were produced for two measures of food insecurity, running out of food and going without food across 595 SA2s. The estimated prevalence of running out of food ranges from 5.4% to 48.6% and averages at 22% whereas that of going without food ranges from 1.1% to 32% and averages at 10.2%. Except for a few outliers, the dispersion of the estimated values approximates a standard normal distribution.

Maps of modelled food security and insecurity reveal a complex picture across the state of NSW. The spatial patterns for the two measures examined in this report are somewhat different. Indigenous households are most likely to run out of food and be without the money to buy more in remoter parts of the state. However, the spatial patterns predicting the location of those who went without food shows that this form of insecurity is most prevalent in urban and inner regional areas.

This is the first attempt to produce small area estimates of Indigenous food insecurity in Australia. Our estimates are presented at the finest possible level of geographical disaggregation for which official data are available for food security and would support enhanced planning and mitigation activities to address the food insecurity problem amongst Aboriginal and Torres Strait Islander households. Though the model-based estimates are consistent with survey-based estimates and have low standard errors, they are somewhat experimental. It is recommended these findings be combined with other forms of knowledge about Indigenous food security and insecurity in NSW when informing policy outcomes.

Future work in the area of Indigenous food insecurity are set to be informed by the 2022-23 NATSIHS, the 2023 National Nutrition and Physical Activity Survey, and within this the 10-item USDA adult food security tool (personal communications, Australian Bureau of Statistics, December 2022).

It is important to note that this report suggests that food insecurity is driven by factors such as access to financial resources, the numbers of adults and children in a household, dwelling quality, and the presence of support networks that may assist in providing access to food when money has run out. The availability of financial resources, rather than access to grocery stores, appears to be driving the patterns of food security observed in the regression models and the maps.

One of the key findings of this study is that going without food is most prevalent in inner regional and urban parts of NSW for Indigenous households. In contrast, running out of food and being unable to afford to purchase more appears to be more prevalent in very remote parts of the state. The data we were able to access provided little guidance in interpreting this geographical disjuncture. This study suggests a continuing importance on food-relief efforts among urban populations, particularly in Sydney.

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CONTACT US

Centre for Aboriginal Economic Policy Research
Research School of Social Sciences
ANU College of Arts & Social Sciences

Copland Building #24
The Australian National University
Canberra ACT 0200
Australia

T +61 2 6125 0587
W caepr.cass.anu.edu.au

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