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How food insecure are people living in Australia

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Research Summary

Why was the research done?

Food insecurity is a hidden and overlooked socio-economic problem in Australia. Data gap is a critical concern in research and practice, as official statistics on food insecurity are neither reliable nor regularly published. In the absence of appropriate data, multiple ad hoc/or US based experiential scale measures are being used by researchers to estimate prevalence of food insecurity, which often generate a wide range of conflicting numbers which are neither reliable nor comparable across settings. A prerequisite to accurate identification of the food insecure is a reliable metric to measure food insecurity.

What were the key findings?

The eight-item Food Insecurity Experience Scale (also SDG indicator to measure Goal 2 of zero hunger) is a reliable tool to measure food insecurity in Australia. Based on alternative approaches to estimating prevalence of food insecurity, in 2020, roughly 2 million people were food insecure in Australia. Interestingly, severe food insecurity is a bigger concern in Australia relative to other OECD countries. South Australia and Queensland were the most food insecure states. Findings also indicate that household level measure of food insecurity may hide intrahousehold hunger. The single-item official measure underestimates food insecurity, while muti-item US based measure may overestimate prevalence of food insecurity.

What does this mean for policy and practice?

If the food insecure are not accurately identified, resources would not be appropriately targeted to households and people who are truly food insecure. Therefore, if Australia continues to rely on experience-based food security measures to monitor food security, then a muti-item scale must replace the single item measures. Additionally, rather than using the US measure, an Australia specific measure should be used. Geographic variation on prevalence estimates warrants tailor-made context-specific policies to address issues related to inadequate access to food. Finally, if the critical issue of intra-household hunger is overlooked, food insecure individuals living in apparently food secure households may miss the benefits of public policy.

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1 Introduction

Parliament of Australia's recently published report on inquiry into food security in Australia (Parliament of Australia, 2023) acknowledges that despite being one of the most food secure nations in the world, food insecurity is a growing challenge in the nation, and an overlooked aspect of Australia's food security. Yet, Australia does not regularly monitor food insecurity. Data gap is a serious concern in translating research into practice. One in twenty-five Australians were food insecure in 2011-12, according to the most recent official statistics on food security reported by 2011/13 Australian Health survey (ABS, 2015). This estimate is based on a single-item measure which was asked in the earlier rounds of National Health Surveys (NHS) and is now included in the Australian Health Survey (AHS): "*In the last 12 months was there any time you have run out of food and not been able to purchase more?*" Respondents who answered 'yes' to this question were asked a follow up question on whether they or other members of the household had gone without food. Based on this follow up question, severe food insecurity in Australia was around 2% in 2010-11 (ABS, 2015). In sharp contrast to these estimates, prevalence rates based on muti-item measures report much higher level of food insecurity (Table A1 in Appendix A summarizes selected studies from the literature). McKechnie et al. (2018) argue that official measures underestimate prevalence of food insecurity in Australia by 5%. FAO (2021) estimates that between 2014-16 and 2018-19, moderate to severe food insecurity in Australia rose from 10.8% to 12.3%. National level statistics also conceal the higher level of food insecurity of vulnerable population groups such as people living in remote communities, single parents, First Nations people (Bowden, 2020). For example, in sharp contrast to the national level average, 31% of Aboriginal and Torres Strait Islander people in remote areas were food insecure in 2011-12 (ABS, 2015). Besides, official measure captures food insecurity at the household level which is likely to conceal intra-household hunger. Furthermore, the single item measure (with the follow up question) only captures a certain level of severity of food insecurity, whereas food insecurity manifests itself in successive stages of increasing severity – ranging from mild and moderate, to extreme forms such as hunger (Hamilton et al., 1997). Hence, chances of under-reporting are higher.

Similar concerns have been noted with the single item measure of hunger on food adequacy included in the household expenditure surveys conducted by India's National Sample Survey Organisation (NSSO, 1993-94).[1] The literature offers multiple arguments explaining the potential danger of subjectivity in using a single question to measure food insecurity (see Maitra & Rao, 2015, for a discussion). However, despite the risk of reporting-bias, Australia continues to rely on the single item metric for food security measurement. In fact, the 2014 General Social Survey (GSS) (module 13.2) and 2015-16 Household Expenditure Survey (HES) include a similar question as a measure of financial stress: *whether a householder went without meals due to financial stress*. Notably, none of these surveys collect the data on a regular basis[2], let alone reporting longitudinal data. The limited sources of panel data are the Longitudinal Survey of Australian Children (Gray & Smart, 2009) and the Household Income and Labour Dynamics in Australia (HILDA) Survey (Watson & Wooden, 2012), which ask a similar question on whether, because of a shortage of money, the respondent had experienced an event such as going without meals.[3]

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[1] NSSO's Household Expenditure and Income Surveys have been including a question on food adequacy since 1983. In 1983 and 1993-94 the question was whether everyone in the household got "two square meals a day" and from 1999-00 the question was revised as "whether everyone in the household got enough food every day."

[2] The GSS is now being conducted on a continuous basis (from 2018), and the first data is made available in GSS 2019.

[3] In HILDA, this question is one of the seven items contained in SCQ, Part C2 (Personal & Household Finances). In 2020, this question is preceded by the phrase: "Since January 2020, did any of the following happen to you because of a shortage of money?"

Given the multiple concerns around food security measurement in Australia, it is no surprise that academic research in Australia has been persistently voicing the urgent need for an Australia-specific measure of food insecurity (see Archer et al., 2017). Paradox of hunger in an apparently food insecure nation is a critical issue. Growing evidence indicate that food insecurity is detrimental to human capital (Burchi & De Muro, 2012; Cook & Frank, 2008), and may result in substantive social and economic costs in the long run. Chronic/acute food insecurity can result in irreversible cognitive or physical damage, leading to increased health expenditures, lost labour productivity, or even mortality (Barrett & Lentz, 2002). Despite these concerns, in many high-income countries, often relatively less attention is devoted to the issue of food insecurity, perhaps driven by an underlying assumption that tackling poverty may automatically largely eliminate hunger. Arguably, it may not be the right approach as food insecurity is a distinct concept and should be regarded as such (Rose, 1999; Maitra & Rao, 2015). In that context, the most important first step in tackling food insecurity must be an accurate identification of who the food insecure are, which in turn is reliant upon a valid and reliable metric to measure food insecurity.

Motivated by the above context, this paper contributes to the discourse on food security measurement in Australia using new data on Food Insecurity Experience Scale (FIES), an eight-item measure developed by the UN Food and Agricultural Organization's (FAO) Voices of the Hungry (VoH) project (see Ballard et al., 2013) and included in the HILDA Survey, for the first time, in 2020. FIES is an indicator of 2020 Sustainable Development Goal (SDG) of zero hunger (2.1.2: Prevalence of moderate or severe food insecurity in the population) which measures economic access to food. FIES is also the only experiential indicator which can measure food insecurity at the individual level, providing population prevalence estimates for people's experience of food insecurity. Using this fresh data, recently, Botha et al. (2024) estimate *one in eleven* (9.1%) individuals to be food insecure in Australia in 2020. I aim to explore this national level data to understand the nature and extent of food insecurity (*FI*, henceforth) in Australia. A key objective of this paper is to examine the internal reliability and validity of FIES in the Australian context and subsequently offer some critical directions for future research to facilitate further exploration of an Australian specific measure of FI. Prevalence of FI is estimated, using two alternative approaches, at the national and state level; and across diverse population groups disaggregated by income, sex, age, ethnicity, family type. The first method reports internationally comparable prevalence estimates based on the common thresholds set on a global reference scale developed by the VoH project (Ballard et al., 2013), while the second approach defines Australia-specific thresholds on the national scale to generate prevalence rates which are not directly comparable across countries but are more meaningful for the purpose of policy related communications within Australia. The study is one of the first attempts to conduct validation exercise for a multi-item tool to measure food insecurity in Australia, using large scale nationally representative data. Furthermore, for the first time, *person level* estimates of food insecurity are reported at *different levels of severity* of hunger. The measure also allows exploring intra-household hunger.

FIES is found to be a valid tool to measure FI in Australia. However, differences exist in how the meaning of the eight items are understood. A range of prevalence estimates are reported, following which, in 2020, 6.42%-9.42% of people (roughly 1.65-2.41 million) were food insecure in Australia; 4.19% of people (roughly 1.07 million) were marginally food secure, 7.31% of people (roughly 1.87 million) were moderately food insecure and 2.11%-3.44% of people (roughly 0.54-0.88 million), severely food insecure. By all specifications, South Australia and Queensland were the most food insecure states in 2020. Interestingly, overall, *one in fifteen* (6.50%) households identified as food secure by the single item measure (*household went without meals*) have food insecure members residing in the household; and majority of them are females. Consistent with the predictions of the literature, certain subpopulations such as people with low income, people with low level of education, people with long term health conditions; lone persons, females, young adults, First Nations People are more likely to be food insecure. Since the next round of FIES data from HILDA will be available only in 2024, the current analysis is cross sectional, and purely descriptive. The results of the study are expected to

provide critical insights into the literature on measurement of FI, and to inform the design of food security monitoring in Australia.

The next few sections of the paper are organized as follows. Section 2 discusses the literature, including the theoretical framework of FIES. Section 3 describes data and the statistical analysis of FIES. Section 4 reports the results and Section 5 discusses the results. Section 6 concludes with some policy implications, and future directions of research.

2 Literature

The literature on measurement of food security has evolved parallelly with the conceptual evolution of food security from the *availability-focused* aggregate (e.g., country/region) level approach to household/and individual level approach focusing on *food access* and *food utilization* (Barrett, 2002). A recent development in the measurement literature are the experience-based food security scales which measure economic access to food. Experiential indicators provide the possibility of analysing FI from a behavioural perspective. The underlying notion is that hunger is resource constrained. Hence, the questions in the multi-item food security scales are always preceded by the phrase "*because you couldn't afford*" or "*because of lack of money or resources.*"[4] The research initiated at the Cornell University resulted in the development of the Radimer/Cornell hunger and food security measures (Radimer et al., 1990) which have been subsequently adopted by the 18-item US Household Food Security Survey Module (US HFSSM) (Hamilton et al., 1997), and Latin American & Caribbean countries (The Latin American and Caribbean Food Security Scale-ELCSA) (Perez-Escamilla et al., 2007), for monitoring purposes at the national level. Other variants of the US HFSSM are the 6-item Household Hunger Scale (HHS) (Ballard et al., 2011) which captures more severe forms of food insecurity, and the 9-item Household Food Insecurity Access Scale (HFIAS) (Coates et al., 2007) which was primarily developed as a cross-culturally validated tool to measure FI in developing countries. FIES is the latest development in this field (Ballard et al., 2013).

2.1 Australian literature

Over the past couple of decades, there has been a rapid proliferation in the volume of research on experiential FI in Australia. Table A1 (see Appendix A) reports a summary of selected studies which used experiential food security measures. Majority of these studies are cross sectional. Only one study uses panel data on the single item measure of *going without meals* reported in HILDA Survey. Majority of studies are descriptive. Small sample size and purposive /convenience sampling are other concerns. Current research is mostly based on the single item questions reported in HES, GSS, NHS or HILDA; or on different variations of US HFSSM reported in independent surveys conducted by the researchers. Only Botha et al. (2024) used muti-item FIES from HILDA 2020, to examine the co-occurrence of FI with respect to other deprivations such as poor physical health or financial hardships. Regarding the prevalence estimates, some key patterns emerge: prevalence rates are higher i) when muti-item scales (e.g. US HFSSM) are used; ii) at regional as opposed to national level (e.g., urban/rural versus national); and iii) for certain sub-populations such as single parent households.

Some of the risk factors for FI, in the Australian context, are poor mental health, disability (Schwartz et al., 2019); chronic health conditions, drug and alcohol use, experience of violence, relationship breakdown and racism (Temple, 2018); childhood trauma (Chilton et al., 2017). As mentioned earlier, the literature identifies some population groups as more vulnerable to FI, such as: people living in remote areas (Pollard et al., 2015),

[4] Rules out the possibility that food secure people may deliberately skip meals for religious, or health related reasons.

First Nations People (Rogers et al., 2018), children (Knowles et al., 2016), single parent households (Vandenberg & Galvin, 2016), people experiencing homelessness (Herault & Ribar, 2017), refugees and asylum seekers (Lawlis et al., 2018).

2.2 Food Insecurity Experience Scale

FIES includes *eight* items which reflect uncertainty and worry about food, inadequate food quality, and insufficient food quantity (see Table 1).[5]

[Table 1 here]

Following Radimer et al. (1990), the theoretical basis for the development of FIES is that the managed process of hunger moves through observable stages as FI increases, characterized, initially by anxiety regarding food access (*worried*), followed by changes in the quality of the diet such as a more monotonous (*fewfood*) or less healthy (*healthy*) diet. At the next stage, there is gradual reduction in quantity through decreases in portion sizes or skipped meals (*ateless*, *skipmeal*, *runout*); subsequently resulting in sharp reduction in intake such as staying hungry (*hungry*) or going a whole day without food (*wholeday*) as FI progresses to a more severe stage. By now, the eight questions in FIES have been tested for reliability and validity in more than 150 countries. Using pooled data collected from the Gallup World Poll Survey for these countries, over a period of three years from 2014-2016, VoH Project developed a *Global Reference Scale* (henceforth *global*) to monitor SDG target 2.1 (see Cafiero et al., 2018).[6] It is important to highlight that the literature recognizes the trade-offs between context specific measures developed from the "ground up" based on extensive ethnographic research (such as the US HFSSM), and a global scale which can be used to measure FI across diverse cultural and socio-economic contexts across the globe (Ballard et al., 2013). While the former may better reflect the experience of FI in each cultural context, the latter has the advantage of generating a measure which is cross-culturally comparable.

2.2.1 Theoretical Framework

The classical one-parameter Rasch model (Rasch, 1960), one of the simplest formulations provided by Item Response Theory (IRT) (see Bond and Fox, 2015), sets the theoretical foundation for constructing the experiential food security scales. IRT models are typically employed to construct educational tests intended to assess *ability* based on an individual's responses to progressively more *difficult* questions. In the food security literature, the unobserved latent trait is *food insecurity* rather than *ability* (see Hamilton et al., 1997*)*, and the item representing the underlying construct are ordered along a continuum of *severity* rather than *difficulty* (Coates et al., 2006). In a Rasch model, the probability that a respondent with ability r_p responds correctly to a test item characterized by difficulty level q_i is modelled as a logistic function of the distance between r_p and q_i (see Cafiero et al., 2018).

$$p \equiv Prob\,(x_{p,i} = 1)|r_p, q_i = F(r_p - q_i) = \frac{e^{r_p - q_i}}{1 + e^{r_p - q_i}} \Leftrightarrow \ln\left(\frac{p}{1-p}\right) = r_p - q_i \quad (1)$$

where $x_{p,i}$ denotes the response of respondent p to item i, r_p denotes the position of the respondent and q_i, that of the item, on the same scale. The scale is an interval measure (with logit units) but not a ratio measure (the

[5] In the HILDA Survey, the wording of the stem question (During the last 12 months, was there a time when, because of lack of money or other resources) was modified by omitting 'other resources', to suit the requirements of population of a developed nation.

[6] The global FIES *reference* scale was created by assigning each item the median value of severity it revealed across datasets from nearly 150 countries and then normalizing them to have mean zero and unit standard deviation.

measures do not have a natural zero point). By coding $x_{p,i}$ as 1 for "yes" and 0 for "no", the log-odds of respondent p affirming item i is a linear function of the difference between severity of FI experienced by p (r_p) and the severity of the item i (q_i). The larger the q parameters are (indicating more severity), the less likely the respondents are to affirm the items. Intuitively, experiences reported by a larger number of subjects are considered less severe, and vice versa. The estimated r parameters are monotonically related to the *raw score* (the number of affirmed items in response to *yes/no* questions), which is an ordinal measure of the latent trait (FI). It is possible to use the raw score as a measure of respondent's severity by imposing two restrictions on the Rasch model: *conditional independence of the responses* and *equal discriminatory power of the items*. The former implies that for respondents at the same level of severity, responses to the various items are uncorrelated. The assumption of *equal discrimination* implies that items have similar power in discriminating among respondents. In other words, it indicates that the ranking in terms of severity of the items should always be the same. Finally, Rasch model requires the assumption of *unidimensionality* which implies that the items included in the scale collectively capture one clearly identified dimension that corresponds to the latent trait of interest – severity of FI in our context. Thus, in the model, FI is viewed as a *continuous*, *unidimensional* and *unobservable* quantity that varies across households (individuals).

In practice, $q_{i,}$ and $r_{p,}$, are typically estimated through maximum likelihood procedures. Subsequently, certain tests and statistics can verify whether the data adequately fit Rasch assumptions. The *conditional independence of the responses* to the eight items is verified by a matrix of correlation among residuals across the eight items. Detection of correlation in the residuals would typically imply that a wording of existing items should be improved so that the meaning is unambiguously conveyed to the respondent. The assumption of *equal discrimination* of the eight items is typically assessed by *fit* statistics, in particular *item infit* statistic, an information-weighted chi-square-like measure of the extent to which an item discriminates more or less sharply than the average item in the module.[7] Items with average discrimination have an infit of 1, and values between 0.7 and 1.3 are considered to be reasonably consistent with the assumption of equal discrimination (Bond & Fox, 2015). Finally, reliability is tested by *Rasch reliability* statistic, which is computed as the proportion of total variance in the population that is accounted for by the measurement model.[8]

2.2.1.1 How to set cut-off points on the scale to determine severity of food insecurity?

For scales, which are consistent with assumptions of the Rasch model, classification into food security categories can be based on *raw score*. Higher raw scores would indicate greater severity of FI. The estimated Rasch item function can be used to indicate where, along the food security scale, respondents have X% probability of affirming an item, which can be used, along with expert judgment, to decide where the cut points should be placed. However, despite best efforts, some degree of arbitrariness may remain in setting cut offs on

[7] Infits are calculated based on the difference between the observed response to a certain item i ($1 = Yes, 0 = No$) and the probability of an affirmative response by the respondent under Rasch assumptions, given the item parameter and the estimated level of severity of FI of the respondent. High infit indicates that an item is not strongly or consistently associated with the underlying latent trait (FI) measured by the other items. Item outfit statistics are like infit statistics except that they are not information-weighted and are therefore particularly sensitive to erratic responses.

[8] With respect to scale analysis, modelled variance is the variance that would exist if all respondents in each raw score had exactly the mean severity and error variance is the variance within each raw score. When presenting Rasch reliability statistics, one would always want to emphasize that these represent reliability within the measured range - omitting extremes, as the standard Rasch reliability statistic is dependent on the distribution across raw scores of respondents in the sample and hence does not consider the extreme cases. In high income countries such as the US or Australia, cases with zero raw score would comprise about 80 percent of the sample. Almost all of these are correctly classified as food secure, so omitting them from the Rasch reliability calculation gives an underestimate of the reliability of the measure for classification. To ensure compatibility of the reliability across countries, a modified version of Rasch Reliability statistics may often be used in which calculation of model/and error variances are weighted equally across the raw scores (see Cafiero et al., 2018).

the scale. Therefore, a key requirement for consistent classification into food security categories is to keep the selected threshold constant over the relevant monitoring period. Nonetheless, to associate a practical meaning to the reported food security statistics, it is desirable to choose as threshold the severity of an item which best describes the experience of FI in the context of the given population (Cafiero et al., 2018).

For global monitoring of Target 2.1 of the 2030 agenda for sustainable development, the VoH Project estimates two prevalence rates: "moderate or severe" (henceforth, *mod+sev*) and "severe" FI. They correspond, respectively, to the severity of the items *ateless* and *wholeday* on the *global reference scale*.[9] It is important to note that the severity of the two thresholds on the *global* scale might not correspond to the severity of any *raw score* level in a particular country. Meaningful cross-country comparison of prevalence estimates is only possible if national results from the application of FIES are adjusted to the *global* scale and computed using the same thresholds. To do so, the measures obtained in any country must be calibrated to the *global* scale (see next section). In practice, if substantive disparities exist across cultural contexts and relative severities differ, an alternative option is to implement probabilistic assignment of food security categories based on the severity parameter and measurement error of each raw score (Ballard et al., 2013).

2.2.1.2 Differential Item Functioning

It is possible for latent distributions to vary across subpopulations. For example, respondents living in different countries or in different regions within the same country, may respond differently to certain items in the scale. When one or more items perform differently for all or some of the subgroups it may indicate differential item functioning (DIF) or bias. In the presence of DIF, prevalence estimates of FI would not be comparable across subpopulations. Items that report statistically significant DIF may have different meanings across subgroups, which may arise from the fact that the items are understood differently by different subpopulations, or the items could be measuring different constructs across subgroups. In that case, development of a global or a national *reference scale* would require establishing the metric equivalence of the scales so as to ensure comparability of prevalence estimates across diverse populations groups. Typically, a set of *anchoring* items are selected (group of items with the same mean and standard deviation of severity) to equate the scales. A brief description of the process of metric equivalence is provided in Appendix B.

3 Materials & Method

3.1 Data

Data for the present study is sourced from 2020 HILDA Survey which is a nationally representative longitudinal study of Australian households commencing in 2001. HILDA provides rich information on family and household formation, income, and work. It began with a large national probability sample of Australian households occupying private dwellings. Since 2001, the sample has been gradually extended to include any new household members resulting from changes in the composition of the original households. In 2020, the original sample comprised 7552 households and 13,467 respondents, while the corresponding figures were 2003 and 3603, for the top up sample. Due to the advent of Covid 19, in Wave 20, 9.6% of the total completed interviews were undertaken by telephone. The first phase of Wave 20 fieldwork was completed (by telephone) in August through to mid-October 2020, while the second phase of fieldwork occurred between late-October 2020 and February 2021(some face-to-face interviews). All people who are interviewed are also asked to complete a separate paper-based questionnaire. Of the 17,070 people who were interviewed in Wave 20, 15,679

[9] In the context of Rasch model, these cutoffs would mean that the lower bound of the range of severity described as *mod+sev* corresponds to the condition of a representative "global" individual or a household that has a 50% probability of reporting having to eat less than they should due to lack of money or other resources. Analogously, the lower bound of the category *severe* corresponds to 50% probability of reporting going an entire day without eating.

(91.9%) returned the self-completion questionnaire (SCQ). FIES module was administered in the SCQ section. All questions were asked with "yes" or "no" response option, and the responses were coded 1 for "yes".

3.2 Statistical Analysis: Food Insecurity Experience Scale, Australia

All parameters are estimated by conditional maximum likelihood estimation technique. FAO offers a customized R-package to implement Rasch model estimation by allowing for complex survey design.[10] For the purpose of this study, I, first estimated the parameters using Stata's *raschtest*, supplemented by calculations based on an excel template to obtain appropriate estimates of fit statistics.[11] Subsequently, results were corroborated using the FAO package.

The parameter estimates are obtained by maximizing the likelihood function conditional on the raw score, using, only cases with *non-extreme* response patterns (that is, with raw score between 1 and 7).[12] In the initial sample of *22,932* individuals, item and respondent parameters are estimated for *1933* respondents, omitting the cases with missing responses (*N=7961*) and those with raw score zero (*N=13038*). Table 2 reports the estimated *item severity* parameters, infit and outfit statistics for the eight FIES items. Table 3 (Column 2) reports the estimated *respondent* parameters, corresponding to raw scores zero to eight. Software reports the "severity" parameters with the mean arbitrarily fixed at "zero". Following the US approach, for presentation purposes, I added seven to the estimated parameters to make them positive (see Bickel et al., 2000).

The eight FIES items comprise an adequately fitting scale of adult food security (henceforth, the *national* scale) with infits in the acceptable range of 0.7 to 1.3 (Table 2).

[Table 2 here]

The pattern of relative item severity in the *national* scale broadly reflects the successive stages of FI established by previous research (Hamilton et al., 1997). Notable exceptions are the items: *worried*, *hungry* and *runout*. In the Australian context severity of *worried* (affirmed by 5.44% individuals) is even greater than that of *ateless* (6.48%) which is meant to represent a more severe condition associated with reduction in portion sizes. On the same note, *hungry* is relatively less severe, its severity being even less than that of *skipmeal*. It is also surprising that the most severe item in the Australian context is *runout*, surpassing the severity of *wholeday*, which, typically represents the most severe form of hunger in most settings.

Conditional correlations among residuals are not excessive for any possible pairs of items, and the residual correlations do not exhibit any discernible pattern. To some extent, the items *ateless* and *skipmeal* exhibit relatively higher residual correlations. Given that the items fit well in the scale, one implication of this result is that care should be taken during the interview to clarify the meaning of the items when administering the survey so that respondents do not get confused about the experience of *eating less that one should* or *skipping a meal*

[10] Available at: https://www.fao.org/in-action/voices-of-the-hungry/analyse-data/en/

[11] The item infit and outfit statistics reported by Stata are in a different formulation than which is needed for assessing fit statistics in food security measurement.

[12] Rasch model cannot calculate scale scores for extreme responses. For the few individuals that affirm all items, the standard solution for this problem is to assign them a score of 7.5. Assigning an appropriate score to those who affirm no items (raw score=0) is problematic as the appropriate scale score is not obvious. However, categorical assignment is unambiguous – these individuals are food secure. For communication purposes a score of zero is appropriate. For analytic purposes, however, no single score is necessarily correct. Depending on the association under investigation, it is the researcher's discretion whether to adjust this assignment or assign lower weights to these respondents to reflect the imprecision of the measure for them or to remove them from the analysis (Hamilton et al., 1997). In the present case, these households have been assigned a scale score of zero.

due to lack of money. Rasch reliability is 0.70 which indicates reasonably good model fit for a scale containing just eight items.

3.3 Setting Threshold on the Food Security Scale: Food security Categories

In this paper, first, to ensure cross-country comparability of prevalence estimates, I estimate prevalence rates using the thresholds for the *global* scale. Next, prevalence rates are estimated using *Australia-specific* thresholds. As explained in Section 2.2.1.1, the former entails probabilistic assignment of food security categories while the latter uses the simple technique based on raw score and discrete assignment of cases to food security classes. In fact, all countries that currently use their own experiential measures of FI for official statistics compute prevalence estimates using the raw score-based method of discrete assignment to food security categories. The latter method has the advantage of being simple and more meaningful for communication to policy makers, media, or the civil society. However, the prevalence estimates based on raw score and discrete assignment would not be internationally comparable (see FAO, n.d.)

3.3.1 Estimating food security prevalence rates in Australia using the Global Standard Thresholds:

Parameters of the *global* scale are adjusted by a linear transformation following the technique described in Appendix B (see results in Table A2, Appendix A). First, *runout* is dropped from the scale and item severities are readjusted using mean and SD of the remaining seven items. Subsequently, *worried*, *skipmeal* and *fewfood* are also removed from the scale, following which the remaining four items *healthy*, *ateless*, *hungry* and *wholeday* exhibit almost equal severity in the two surveys (correlation between common items: 99.4%). As Figure 1 shows, their relationship is now almost linear, providing inferential evidence that these items reference similar objective conditions in the *national* versus *global* context.

[Figure 1 here]

The item calibration of the global scale is now standardized using the mean and SD of these four items (see results in Col. 9, Table A2). Figure 2 reports a comparison of severity ordering of items in the *national* scale with those of the *unadjusted* as well as *standardized* global scale.

[Figure 2 here]

The threshold used to identify food security status using the two scales should now generate comparable estimates of prevalence of FI. Following Cafiero et al. (2018), probabilistic assignment of food security status is implemented (see Table A3, Appendix A).

3.3.2 Estimating food security prevalence rates using Australia-specific thresholds

It is worthwhile to estimate prevalence of FI using thresholds which would most appropriately describe the experience of FI in the Australian context. Since the eight FIES-items satisfy the relevant Rasch model assumptions, in this scenario, it is possible to implement the simple classification based on discrete assignment to food security classes based on raw scores. For the purpose of this analysis, following the US approach (see Bickel et al., 2000), four categories of food security are identified - highly food secure, marginally food secure, moderately food insecure (low food security) and severely food insecure (very low food security).

Cut-off selection to identify the *Food Insecure*. An appropriate threshold to demarcate FI may correspond to the severity of the item *healthy*, since being "*unable to access healthy and nutritious food*" seems to be a key expression of FI in the Australian context. Cultural values are likely to influence how people think about food; and the concept of holistic health appears to be an integral aspect of Australian food culture. For example, Akbar et al., (2022) recently conducted an exploratory analysis to develop the conceptualization of household food security by Maori and Pasifika people living in the south-east Queensland, which underpins food security as an essential aspect of culture and holistic health. Although the latter entails much more than eating healthy,

nonetheless, access to affordable and nutritious food is undoubtedly one of its critical components. Enabling equitable access to healthy and sustainable diets is also one of the five key themes identified by CSIRO Futures (Wynn et al., 2023) in its extensive report on path forward to reshape Australia's food systems. To a considerable extent, Australia's growing concerns with obesity and non-communicable diseases also makes access to healthy and nutritious food a key aspect of food security (Burns, 2004). If *healthy* is the selected marker of FI, the raw score for placing the threshold to demarcate the food secure and food insecure individuals corresponds to 2+, that is, individuals with $2 \leq raw\ score \leq 8$ (those who affirm at least 2 items) are classified as food insecure.

Cut-off selection to identify the *Severely Food Insecure*. Consistent with the *global* scale, the threshold for *severe FI* is labelled at the severity level of the item *wholeday.* In the Australian context *wholeday* may be a valid marker for identifying severe FI as it aligns with the question on *whether a householder went without meals due to financial stress*. In that context, another possibility is to set the cutoff at the severity level of *skipmeal*. However, in the current scenario, *wholeday* is preferred because psychometric assessment indicates some overlap in respondents' perception of *skipmeal* with respect to *ateless* and *hungry*. Another contender for the marker of severe FI is the item *runout*, in line with the AHS (ABS, 2015) question on *household running out of food and not being able to purchase more*. However, Rasch analysis reveals that this item might be too severe in the Australian context indicating potential bias. Further investigation is recommended before *runout* can be used as an appropriate threshold for demarcating severe FI. The threshold at the severity of *wholeday* roughly correspond to raw score $7+$, which is used as the cutoff to identify the *severely* food insecure individuals (those who affirm at least seven items).

Therefore, using 2+ and 7+ as cut-offs to demarcate FI and severe FI, respectively, individuals with $2 \leq raw\ scores < 7$ are identified as *moderately food insecure* (low food security) and those with $7 \leq raw\ scores \leq 8$ are identified as severely food insecure (very low food security). Intuitively, a moderately food insecure individual is one who, over the duration of the reference period, is unable to access healthy and nutritious food and may also worry about not getting enough food or may reduce the size of meals or skip meals and may experience hunger. However, this individual does not experience the most severe forms of FI which are experienced by a *severely food insecure individual* - going without food a whole day or living in a household which runs out of food.

Highly Food Secure* and *Marginally Food Secure. The threshold for identifying the *marginally food secure* households is placed near the severity level of the item *fewfood*. Hence, all individuals with raw score $zero$ (that is, those who denied all FIES items) are categorised as *highly food secure*, and those with raw score 1 are identified as *marginally food secure*. Intuitively, while a *food secure* individual experiences none of the FI conditions stated above over the past 12 months, a *marginally food secure* individual eats a more monotonous diet than desired (*fewfood*). However, this individual does not worry about not having adequate food (*worried*) or sacrifice quality (*healthy*) or quantity (*skipmeal*, *ateless, hungry, wholeday, runout*).

Based on the above cut offs, the measured range of FIES Australia is # 4.37 logistic units ranging from 4.82 to 9.19[13] (Table 3). Prevalence of FI (unweighted) in Australia is 9.58% in 2020, of which 7.38% indicate moderate FI and 2.20%, severe FI. Prevalence of marginal food security is 4.56%. The scale reports high sensitivity (.80) and specificity (.95).

[Table 3 here]

Table 4, reports the prevalence estimates using weighted person-level data, based on these preferred Australia-specific cutoffs (henceforth, *national reference* thresholds): *fewfood* ($raw\ score = 1$), *healthy* ($raw\ score \geq 2$)

[13] Score 10.21 not considered, being a pseudo-value based on raw score 7.5.

and *wholeday* ($raw\ score \geq 7$) as upper bound of marginal FI, and lower bounds of moderate and severe FI, respectively.

[Table 4 here]

Table 5 reports prevalence estimates using the cross nationally comparable *global reference* thresholds (*ateless* and *wholeday*). It also reports sensitivity analysis using alternative Australia-specific thresholds to define moderate and severe FI.

[Table 5 here]

3.4 Estimating Rasch model across Australian States

Rasch model is estimated for eight states of Australia - New South Wales (NSW), Victoria (VIC), Queensland (QLD), South Australia (SA), Western Australia (WA), Tasmania (TAS), Northern Territory (NT), and Australian Capital Territory (ACT). After removing extreme responses NT is dropped from the analysis due to extremely small sample size ($N = 9$). ACT too has a small sample ($N = 22$), hence results should be treated with caution. Tables A4 and A5 (Appendix A) report the estimated item parameters and fit statistics, respectively, for the seven states. The item fit statistics are in the acceptable range for all states, except ACT which reports high infits for *wholeday* (1.40) and *runout* (1.66), indicating somewhat weak association of the items with the measured latent trait (FI). As before, Rasch reliability is in the range of 70 across all states, and relatively higher residual correlations are noted for *ateless* and *skipmeal*.

With respect to the *global* scale, DIF is detected for *worried* and *runout* in *all* states (see Figure A2). Additionally, DIF is detected for *fewfood* and *skipmeal* in NSW, VIC, QLD and WA; for *healthy*, *skipmeal* and *hungry* in SA; for *hungry* and *skipmeal* in TAS; and for *fewfood* and *hungry* in WA. As before, the presence of DIF implies that these items are removed, and the scales (*global* versus *states*) are equated using the same iterative process described above in Section 3.3.1. Internationally comparable prevalence rates are estimated using the global reference thresholds *ateless* and *wholeday* to identify *mod+sev* FI and *severe* FI, respectively (see Table 5).

Prevalence rates based on the *national reference* thresholds are reported in Table 4. To allow meaningful comparison with the national level estimates, the same equating process is followed again. This time, the *national* scale is first standardized with respect to the *state* level parameters estimates. Figure A2 (Appendix A) reports a comparison of items in the *state* versus the *standardized national* scale. National respondent parameters are also adjusted using the mean and SD of the items that appear to be equivalent in the two scales (see Figure A3).

3.5 External validation of FIES Australia

Recently, Botha et al. (2024) examine the association of FIES, with respect to multiple other measures of deprivation including inadequate economic resources, poor financial wellbeing, housing stress, low levels of social support, poor mental and physical health; and find that FI co-occurs with other hardships. These finding establish external validation of FIES in Australia. In this analysis, I, further examine the descriptive association of food security status (based on the *national reference* thresholds) with selected demographic and socio-economic characteristics of individuals. An ordered probit model is estimated using three categories of food security status: food secure ($= 0$), moderately food insecure ($= 1$) and severely food insecure ($= 2$).

4 Results

4.1 Prevalence of FI in Australia

Following Table 5, using *national* thresholds prevalence of severe FI ranges from 1.21% (threshold: *runout*) to 2.11% (threshold: *wholemeal*), while prevalence of moderate FI ranges from 3.89% (*national* thresholds: *ateless* and s*kipmeal*) to 8.20% (*national* thresholds: *healthy* and *runout*). Based on the *global reference* threshold (*wholemeal*), prevalence of severe FI is 3.44% & the prevalence of *mod+sev* FI is 6.42%. However, overall prevalence of FI is around 9.4% based on the *national* reference threshold (*healthy*).

By all specifications, SA is the most food insecure state, prevalence of FI ranging from 8.69% (*global reference* thresholds) to 11.16% (*national reference* thresholds), closely followed by QLD –corresponding figures being 7.70 % to 11.03%, respectively. Using *global reference* thresholds, prevalence of FI is also higher than national average in TAS (7.48%) and WA (6.03%). Using *national reference* thresholds, NSW (9.53%) reports higher prevalence compared to TAS (8.71%) and WA (8.17%). Across all specifications (excluding *runout*), severe FI is the highest in QLD, ranging from 3.06% to 4.44%, followed by SA (2.99%-4.27%) and TAS (2.04% -5.17%). Interestingly, using *runout* as the threshold for severe FI, NSW and VIC report relatively higher prevalence of severe FI – 1.13% and 0.93%, respectively, relative to TAS (0.69%) and WA (0.67%). Marginal food security. is 4.19% in Australia.

The timing of the survey offers an opportunity to exploit temporal variation in FI in 2020 because the first phase of Wave 20 fieldwork was completed (by telephone) in August through to mid-October 2020 when infection rates were fast rising with strict lockdowns and restrictions prevailing in some parts of Australia such as Melbourne and Sydney. The second phase of fieldwork occurred between late-October 2020 and February 2021 when some face-to-face interviews were possible as restrictions were gradually relaxed. Following this timeline, prevalence rates were 8.86% during the first phase, and 17.18% during the second.

4.1.1 Intra-household FI

The single item measure *'going without meals'* measures FI at the household level. It is interesting that about 6.50% of households which are identified as food secure by this metric (those who responded "no" to the question), also have one or more members who are identified as food insecure using FIES (see Table 6), indicating the presence of intra-household FI.

[Table 6 here]

The proportion of such apparently food secure households (with food insecure members residing within the household) is the highest in QLD (7.45%), and the lowest in ACT. Additionally, majority (62%) of the households have female food insecure members–out of 518 households indicating intra-household hunger, 323 have food insecure members who are females. Again, the proportion of such households is the highest in VIC (4.38%), closely followed by QLD (4.18%) and NSW (3.96%). On a similar note, almost 47% of households have food insecure members who have long term health conditions, the overall proportion of such households being the highest in SA (3.92%). Around 27% households have food insecure members who are younger than 20 years, while almost 36% are married with dependent children.

4.2 Socio-economic Correlates of Experiential FI in Australia

Table 7 reports predicted probabilities of belonging to different food security categories, given the rest of the variables are at their mean values.[14]

[14] Marginal effects are reported in Appendix (Table A7).

[Table 7 here]

As expected, higher risk of moderate and severe FI is noted for individuals with lower income, lower level of education, people living in areas in the lowest deciles of SEIFA[15] rankings, First Nations People, people who are divorced or separated, people who are unemployed, females, lone persons, people with long term health conditions. For example, the predicted probability of being moderately or severely food insecure is roughly 10% for individuals with low education (< year 11) compared to only 6% for those with an education level of bachelor's degree or higher; 14% for the First Nations people as opposed to only 9% for the non-indigenous population; 14% for young adults (<20 years) as opposed to only 6% for the elderly (>60 yeas); 14% for lone persons relative to 6% for couples with no child, and 7% for couples with dependent children. The risk of being moderately or severely food insecure was 12% during the second phase of the survey when restrictions were easing out, relative to only 9% during the first phase when strict lockdown was in force.

Predicted probabilities at representative values also generate valuable insights. For example, all else constant, predicted probability of being moderately food insecure is 4% for an Australian male aged 36 years, who has completed high school, who lives in NSW in a family of four with two kids, is employed and belongs to the top 60% of income distribution, and has no long-term health condition. Changing income group to the lowest 40% of income distribution increases the chance of being moderately FI for this representative person to 8.3% ; and making him unemployed increases the risk to 15.4%. If the representative person is changed to a female, the risk increases further to 16.9%. Risk of moderate FI increases to 19.9% for this person during the second phase of the survey (restrictions easing), while it decreases to 16.7% during the first phase of interviews (strict lockdown).

5 Discussion

Rasch analysis reveals that the eight FIES-items fit well in the scale, establishing reliability and validity of the scale. However, differences exist in the severity ranking of items in the *national* versus the *global* reference scale. Particularly problematic are the items *worried* and *runout* as both items rank relatively higher in terms of severity in the *national* scale. Additionally, there is an indication of overlap in the understanding of the items *ateless* and *skipmeal*. It is also possible that the items represent somewhat different objective conditions in the Australian context. Another possibility is response-bias introduced by the survey year. HILDA wave 20 data was collected during the peak period of COVID 19 (started August 2020 and completed February 2021), an unusual period in many ways, which may have induced the biases, subsequently influencing the severity ranking of items.

Using the *national* reference thresholds (*healthy* and *wholeday*), in 2020, 7.31% or *one in fourteen* people (roughly 1.87 million) were moderately food insecure and 2.11% or *one in forty-seven* people (roughly 0.54 million) were severely food insecure. Overall, 9.41% or *one in eleven* people (roughly 2.41 million) were food insecure, which align with the prevalence estimates reported by Botha et al. (2024). Following the *global* reference thresholds (*ateless* and *wholemeal*), the prevalence rate for *mod+sev* FI was 6.42% or *one in sixteen* (roughly 1.65 million) people and that for severe FI was 3.44% or *one in twenty-nine* (0.88 million) people. Considering both specifications, it is safe to say that approximately *2 million* people were food insecure in Australia in 2020.

To situate the results in the broader context, prevalence rates based on the *global* thresholds are compared with those from comparable OECD regions and Oceania as reported in FAO (2023). In 2020, prevalence of severe FI was higher in Australia (3.44%) relative to Oceania (2.6%), although *mod+sev* FI is reported to be much higher in Oceania - 12.1% as opposed to 6.4% in Australia. Comparing the prevalence rates with North America

[15] SEIFA stands for Socio-Economic Indexes for Areas.

and Europe, prevalence of severe FI is higher in Australia relative to North America (0.7%), Southern Europe (2.4%), Northern Europe (1.2%) and Western Europe (0.8%). However, *mod+sev* FI is lower in Australia compared to North America (8.3%), Southern Europe (9.3%) although it is higher than Western Europe (3.9%) and Northern Europe (4.2%). The broad implication of these results is that FI, especially severe FI, is a greater concern in Australia relative to many other OECD countries.

A direct comparison of prevalence estimates reported in the present study with those from other studies conducted in Australia is difficult as the current analysis reports *person* level estimates of prevalence of FI, while the bulk of the literature on experiential FI in Australia report *household* level estimates. The present analysis is only comparable to Botha et al. (2024) who find household reports of FI to be higher than individual reports – 13% (*one in seven*) households reported having at least one or more food insecure member. Also, based on the question on '*going without meals'*, prevalence of FI is 3% only. Therefore, overall, the analysis confirms the argument that single item measures underestimate the prevalence of FI in Australia. One immediate implication of this claim could be that AHS 2011/13 question on food running out (including the response to the follow up question on going without food) is only capturing a severe form of FI. If this is indeed the case, then there is a serious concern that the moderately food insecure and marginally food secure population are left out of the realm of public policy. After all, 4.19% or *one in twenty-four* (roughly 1.076 million) people were marginally food secure in 2020. Finally, it is also important to note that the US muti-item scale overestimates the prevalence of FI in the Australian context. Taken together, these results confirm the critical importance of using an Australia specific muti-item measure of food security for monitoring purposes.

The analysis reveals potential presence of intra-household hunger – *one in fifteen* (6.50%) households which are identified as food secure by the single-item measure (*going without meals*) have food insecure members residing within households. As mentioned above, using the same data, Botha et al. (2024) also find evidence of intra-household food insecurity. In the context of the present analysis, it is concerning that majority of these food insecure members are females. This finding is consistent with the broader literature on intrahousehold resource allocation (Behrman, 1993). Further investigation is needed to understand what drives this outcome in the Australian context.

At the regional level, QLD and SA are the most food insecure states, closely followed by TAS. In the absence of comparable data, an approximate validation of this pattern is obtained from the single item question on going without meals reported in HILDA 20. Proportion of respondents who report that they went without meals due to shortage of money is the highest in SA (4.81%), followed by QLD (4.11%) and TAS (3.95%). Relatively higher levels of FI in SA, QLD or TAS could be driven by many factors such age-gender composition and education level of the population, family structure, food behaviour. For example, SA, QLD, and TAS report lower proportion of people with non-school qualification (ABS, 2016). Another important consideration is income–in 2020-21, TAS recorded the lowest median total income, and South Australia recorded the slowest growth rate since 2016-17 (ABS, 2023).

The descriptive analysis on socio-economic correlates of FI establishes construct validity. Most associations are in the expected direction, aligned with the predictions of the literature. Couple families (with or without dependent children or with no child) are found to be less food insecure relative to lone persons. Similar observations are noted in the US – a higher proportion of men and women living alone are reported to have low food security or very low food security in 2021, relative to married couple families (Coleman et al., 2022). Older people (>60 years) are found to be less food insecure relative to young adults (<20 years). The Australian literature offers mixed evidence on elderly food insecurity. As such ageing by itself is not a risk factor for FI (Quine & Morrell, 2006; Temple et al., 2019), however poor health and living conditions may make them vulnerable to FI (Forsey, 2018). Interestingly, the prevalence of moderate and severe FI was higher during the second phase of the survey when restrictions started easing out. The result is plausible as the economic impact of job or/income loss could have been felt with a lagged effect (Kent et al., 2022; Rogers et al., 2021).

6 Conclusion

This paper examines the validity of FIES, the eight-item measure of economic access to food developed by FAO's VoH Project and included in the HILDA Survey, for the first time, in 2020. Subsequently, prevalence of food insecurity is estimated using two alternative techniques. The first method estimates internationally comparable prevalence rates, by calibrating the national level measures against the global reference scale. Setting cutoffs at the threshold of the severity of the items *ateless* and *wholeday*, two prevalence rates are estimated: *mod+sev* and *severe* food insecurity, respectively. The second method is based on raw score and discrete assignment of cases to food security categories. In this scenario, Australia specific thresholds are selected. The preferred national reference thresholds are set at the severity levels of the items *fewfood*, *healthy* and *wholeday*. Accordingly, four categories of food security status are identified: highly food secure, marginally food insecure, moderately food insecure (low food security) and severely food insecure (very low food insecurity). It is important to keep in mind that raw score-based classification and estimates of prevalence rates do not allow cross country comparison (see FAO, n.d.). Finally, external validation of FIES is conducted by examining the association of the various categories of food security status (based on *national reference* thresholds) with selected socio-economic and demographic characteristics of individuals.

In 2020, approximately 1.07 million people were marginally food secure, 1.65-1.87 million were moderately food insecure and 0.54-0.88 million were severely food insecure in Australia. Overall, 1.65-2.41 million (6.42%-9.42%) people were food insecure. I have reported a range of prevalence estimates. As to the question of which threshold to use it is important to keep in mind again that the most important uses of the food insecurity measures is typically in examining changing severity over time and space, across population groups. Accordingly, stability is considered more important than reaching universal agreement on the appropriateness of each dividing line between categories (Bickel et al., 2000). The choice of method to estimate prevalence rates would also depend on the goal of the analysis. If the main aim is to obtain globally comparable estimates, then the FAO approach based on global reference thresholds should be used. However, if the main objective is simplicity and ease of communication within the country, then the raw score-based discrete assignment to food security classes using national reference thresholds should be preferred. The latter approach has the advantage of being more meaningful when results are conveyed to decision makers, media, or civil society (Nord, 2012). It must be noted that a similar principle applies to analysis of subpopulations within a given country – the same calibration technique must be followed in comparing prevalence estimates based on *state* versus the *national* level data.

Implications of the results are many: First, if Australia continues to rely on experience-based food security measures to monitor food security, then a muti-item scale must replace the single item measures as the latter continually underestimate the prevalence of food insecurity. Furthermore, the single item measure is unable to distinguish between different levels of food insecurity in the same way the muti-item scale does. For example, for policy purposes marginally food secure and highly food secure populations should be treated differently even though technically both groups are identified as food secure. Second, the single item official measure reports food insecurity at the household level, concealing the critical issue of intra-household hunger. Third, if a muti-item measure is adopted as the designated metric to measure national level food insecurity, then rather than using the US measure, an Australia specific measure should be used. The former typically overestimates food insecurity in Australia. This argument somewhat contradicts Parliament of Australia's (2023) recommendation (no. 29) of conducting surveys of household food insecurity every three years using the US HFSSM. Next, it is critical to avoid a one-size-fits-all policy regarding food security as disaggregated estimates of prevalence of food insecurity across diverse settings/ and subpopulations reveal a divergent picture. The current analysis also demonstrates a simple and cost-effective technique of predicting food security status using the information on certain demographic and socio-economic characteristics of individuals. These characteristics can be used as proxy indicators of food insecurity, as argued by previous research (Haddad et al., 1994). Although such predictions are likely to be more meaningful and accurate if causality can be ensured. The most

food insecure states in the current analysis – South Australia, Queensland, and Tasmania – warrant tailor-made context-specific policies to address issues related to inadequate access to food.

The present analysis has its limitations. First, it is based on cross section data which restricts the possibility of examining the risk of falling into and out of food insecurity. It also prevents more rigorous analysis of determinants or consequences of food insecurity using fixed effects. Hence, the analysis presented in this paper is purely descriptive. Additionally. small sample size is a concern for the heterogeneity analysis across states. Finally, the data relates to 2020 which is typically not a *normal* year (due to Covid 19), hence may have some response bias.

Future research should focus on causal analysis of determinants and consequences of food insecurity in Australia. Such efforts will add rich insights into social costs of food insecurity, in addition to facilitating accurate identification of the food insecure. Finally, to allow regular monitoring of food security, data must be collected consistently, preferably, longitudinal data. It is worth noting that if muti-item scale measures are to be used for targeting resources and for monitoring, it will be useful to have a suit of indicators (such as dietary diversity indicators, nutritional status) in the same dataset to ensure robustness (Ballard et al. 2013, p.12). Modules such as FIES offer a simple, cost-effective option with low response burden, which can easily be added in national level surveys to conduct regular monitoring. Importantly, FIES has the flexibility of being tailored to measure food insecurity at the household or individual level as necessary, and hence offers a cost-effective tool to identify intra-household hunger. However, if US HFSSM is used for monitoring purposes, then suitability of the wordings of the items must be tested first via rigorous psychometric analysis, subsequently examining metric equivalence across sub populations. Otherwise, prevalence estimates would not be comparable. It seems, an efficient strategy, in the long run, would be to develop an Australia-specific tool from the ground up based on ethnographic research similar to that of the US. Although the set-up cost of such an effort maybe high, given the diversity of food related experiences across cultures, especially, among the First Nations people, such actions are likely to generate relatively higher benefits per dollar of investment in the longer run. Besides, actions to improve the quality of national food security statistics are consistent with Australia's 2030 Agenda for Sustainable Development Goals which underpin closing data gaps (DFAT, n.d.).

Tables & Figures

Table 1: FIES - items and their abbreviations by hypothesized conceptual domain.

Item abbreviation	Description	Domain
worried	were worried you would not have enough food to eat?	uncertainty, anxiety
healthy	were unable to eat healthy and nutritious food?	quality
fewfood	ate only a few kinds of foods?	quality
skipmeal	had to skip a meal?	quantity
ateless	ate less than you thought you should?	quantity
ranout	household ran out of food?	quantity
hungry	were hungry but did not eat?	quantity
wholeday	went without eating for a whole day?	quantity
Note: In HILDA, Wave 20, FIES module, all questions are preceded by the phrase**: "***During the last 12 months, was there a time when, because of lack of money you/your …"*		

Table 2: Item severity parameters and fit statistics, eight-item adult food security scale (N = 1933), Australia, 2020.

Item	Percent affirmed	Severity parameter	Std. error	Item infit	Item outfit
fewfood	8.96	5.68	0.099	1.01	1.01
healthy	7.34	6.26	0.092	1.22	1.28
ateless	6.48	6.62	0.091	1.05	1.01
worried	5.82	6.83	0.103	0.75	0.65
hungry	5.44	7.06	0.095	0.86	0.79
skipmeal	5.10	7.21	0.101	1.03	1.03
wholeday	3.81	7.87	0.058	0.88	0.80
runout	3.07	8.46	0.012	1.20	1.31
Note: Estimated obtained using Stata Raschtest (fit statistics computed by the author using separate excel template) /and FIES app available at: https://www.fao.org/in-action/voices-of-the-hungry/analyse-data/en/ . Estimation method: Conditional Maximum Likelihood. No. of groups: 9 (7 of them are used to compute the statistics of test). Number of individuals: 22932 (7961 individuals removed for missing values). Number of respondents with null or perfect score: 13038 (these respondents are omitted from the psychometric analysis). Conditional log-likelihood: -5019.5966. Reported item severities have been obtained by adding seven to severity parameters reported by the software.					

Table 3: Individual scale scores, food security status categories and prevalence rates (unweighted) according to the 8-item FIES, Australia 2020.

Raw score	Severity	S. Error	Frequency *(N=14971)*	% of individuals	Cumulative %	Prevalence of FI (unweighted)
0	Not defined	-	12855	85.87	85.87	Highly food secure 85.87%
1	4.82	1.10	682	4.56	90.42	Marginally food secure 4.56%
	5.28	Threshold moderately food insecure				
2	5.74	0.86	357	2.38	92.81	Moderately food insecure 7.38%
	6.07					
3	6.40	0.78	249	1.66	94.47	
4	6.99	0.76	172	1.15	95.62	
5	7.58	0.78	161	1.08	96.69	
6	8.25	0.87	166	1.11	97.80	
	8.72	Threshold severely food insecure				
7	9.19	1.11	146	0.98	98.78	Severely food insecure 2.20%%
8	10.21	1.49	183	1.22	100.00	

Note: [a]The severity parameters are continuous interval-level measures of the extent of food insecurity or hunger for the individual. The zero point on the Rasch Scale is arbitrary. Reported scale severities have been obtained by adding seven to severity parameters reported by the software. The severity of food insecurity with raw score zero and eight is unknown. The tables for raw score 8 was calculated as if for raw score 7.5. Food security scale has a measured range of 4.37 logistic units: 4.82 to 9.19 (10.21 not considered, being a pseudo-value based on raw score 7.5). Prevalence rates have been computed for 14971 households.

Table 4*:* Prevalence (weighted) estimates (using national reference thresholds) across four categories of Food Security, Australia, 2020.

Setting	N[a]	Highly FS (%) (raw score=0)	Marginally FI (%) (raw score=1)[b]	Moderately FI (%) (2 ≤ raw score <7)[c]	Severely FI (%) (7 ≤ raw score <=8)[d]	FI (%) 2 ≤ raw score ≤8
Australia	14971	86.40	4.19	7.31	2.11	9.42
NSW	4228	86.41	4.06	7.66	1.87	9.53
VIC	3910	87.32	3.98	6.91	1.78	8.69
QLD	3266	83.99	4.99	7.97	3.06	11.03
SA	1321	85.15	3.69	8.17	2.99	11.16
WA	1344	88.37	3.46	6.57	1.60	8.17
TAS	499	85.81	5.48	6.67	2.04	8.71
ACT[e]	312	91.52	5.17	2.42	0.89	3.31

Note: Prevalence estimates are based on weighted person level data from HILDA Survey 2020. [a]Prevalence rates are estimated including extreme responses. [b]Threshold corresponds to the severity of *fewfood*, [c]threshold corresponds to the severity of *healthy*, [d]threshold corresponds to the severity of *wholeday*. [e]Prevalence estimates for ACT may not reliable due to small sample size.

Table 5: FIES-based Prevalence of Food Insecurity by various specifications: Australia 2020

	Using Australia specific thresholds										Using FAO global reference thresholds	
	Moderate (%)						Severe (%)			FI (%)	Moderate+ Severe %)	Severe (%)
Setting	(2 ≤ raw score <7) using *healthy*[a] & *wholeday*	(2 ≤ raw score <6) using *healthy* & *skipmeal*	(2 ≤ raw score <8 using *healthy* & r*unout*	(3 ≤ raw score <6) using *ateless* & *skipmeal*	(3 ≤ raw score <7) using *ateless* & *wholeday*	(3 ≤ raw score <8) using *ateless* & *runout*	(7 ≤ raw score <=8) using *wholeday*[b]	(6 ≤ raw score <=8) using *skipmeal*	(raw score =8) using *runout*	(2 ≤ raw score <=8) using healthy[c]	*ateless & wholeday*	*wholeday*
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
Australia	7.31	6.26	8.20	3.89	4.95	5.84	2.11	3.15	1.21	9.42	6.42 0.60)	3.44 (0.44)
NSW	7.66	6.83	8.39	4.16	4.98	5.72	1.87	2.69	1.12	9.53	5.86 1.09)	2.78 (0.74)
VIC	6.91	5.72	7.76	3.39	4.59	5.44	1.78	2.98	0.93	8.69	5.48 (1.09)	3.0 (0.80)
QLD	7.97	6.78	9.19	4.52	5.71	6.93	3.06	4.25	1.84	11.03	7.70 1.40)	4.44 (1.04)
SA	8.17	7.09	9.03	4.16	5.27	6.10	2.99	3.98	2.04	11.16	8.69 (2.35)	4.27 (1.64)
WA	6.57	5.26	7.50	3.60	4.91	5.83	1.60	2.91	0.67	8.17	6.03 (1.98)	2.96 (1.50)
TAS	6.67	5.94	8.05	4.02	4.77	6.13	2.04	2.79	0.69	8.71	7.48 (3.60)	5.17 (2.58)
ACT	2.42	2.42	2.69	0.61	0.61	0.88	0.89	0.89	0.62	3.31	3.11 2.92)	1.82 (2.32)

Note: In Columns (2-11), prevalence estimates are based on weighted person level data from HILDA Survey 2020. [a] Lower bound of national reference threshold to demarcate moderate FI is at the severity level of *healthy*. [b] Lower bound of national reference threshold to demarcate severe FI is at the severity level of *wholeday*. [c]National reference threshold to demarcate food secure from the food insecure is at the severity level of *healthy*. Some numbers in Col.11 may not add up due to rounding. In Clumns 12 & 13, standard errors are reported in parenthesis.

Table 6: Intra-household hunger: proportion of food secure[a] HHS with one or more food insecure members (by selected demographic/socio-economics characteristics), Australia, 2020

Total HHs (1)	Percentage of HHs with intra-HH FI (2)	Females (3)	Low income (4)	Long term health conditions (5)	Age group (6)	Married (7)
Australia	6.50	3.84	3.73	2.88	1.66	2.20
NSW	7.02	3.96	3.70	2.49	1.68	3.26
VIC	6.22	4.38	3.53	3.02	1.73	2.59
QLD	7.45	4.18	1.54	3.29	1.77	3.26
SA	6.22	3.48	4.84	3.92	2.15	3.31
WA	4.83	2.67	3.75	2.55	1.35	2.18
TAS	5.87	3.24	4.27	3.26	1.22	3.47
ACT	3.75	0.40	1.29	1.29	0.64	1.28
Note: [a]Food secure HHs are those who respond "no" to the question on going on without meals in the past 12 months. Reported percentages are based on population level weights.						

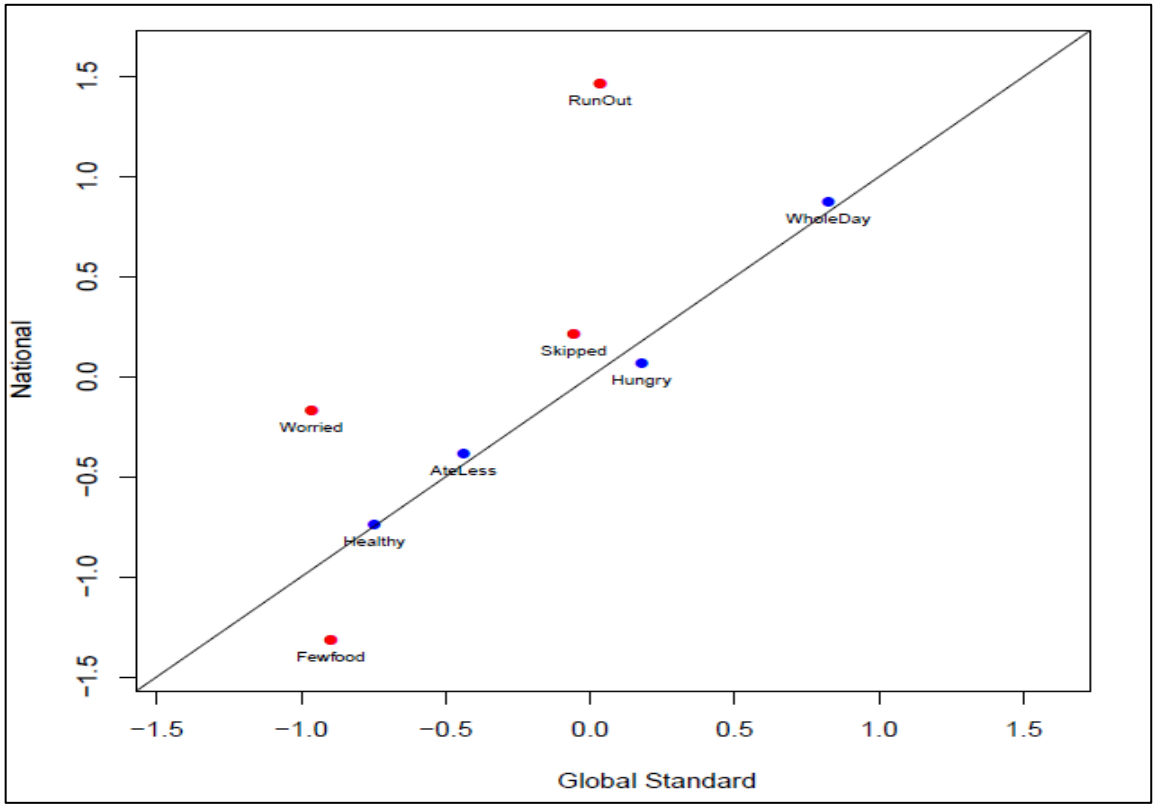
Table 7: Factors affecting Food Security Status: Predicted Probabilities from Ordered Probit Model: Australia 2020

	Food Secure (N= 12,855)	Moderate FI (N=1105)	Severe FI (N=329)
Income status			
lowest 40%	0.873	0.097	0.030
top 60%	0.932	0.055	0.013
Highest education level achieved			
< year 11 (==0)	0.898	0.078	0.024
bachelor's degree or above	0.942	0.047	0.011
completed HS but below bachelor's degree	0.892	0.082	0.026
Remoteness Area			
major cities (=0)	0.900	0.076	0.024
outer regional/remote	0.907	0.071	0.022
inner regional	0.911	0.069	0.021
2001 Decile of Index of relative socio-economic disadvantage			
lowest decile	0.920	0.063	0.017
2nd decile	0.877	0.092	0.031
top 10% (=0)	0.932	0.054	0.014
Aboriginal or Torres Strait Islander origin			
not indigenous (=0)	0.906	0.072	0.022
indigenous	0.864	0.100	0.036
Long term health conditions			
no (=)	0.931	0.056	0.014
yes	0.846	0.113	0.04
Marital status			
never married (=0)	0.919	0.062	0.019
married	0.890	0.082	0.028
separated or divorced	0.892	0.080	0.027
widowed	0.918	0.063	0.019

Current labour force status			
Employed (=0)	0.922	0.062	0.016
unemployed	0.854	0.108	0.038
not in the labor force	0.881	0.090	0.029
Age group			
<20 (=0)	0.860	0.103	0.037
20-30	0.820	0.127	0.052
35-45	0.848	0.111	0.041
45-60	0.889	0.084	0.027
60-70	0.955	0.037	0.008
>=70	0.986	0.013	0.002
Family type			
lone persons (=0)	0.858	0.107	0.036
couple family without children	0.936	0.052	0.012
couple family with dependent children	0.926	0.059	0.015
couple with no dep children	0.920	0.064	0.016
Kids	0.904	0.073	0.023
Sex			
Male (=0)	0.910	0.069	0.021
female	0.899	0.077	0.024
Time			
Phase 1: strict lockdown period	0.881	0.089	0.03
Phase 2: restrictions relaxing (=0)	0.906	0.072	0.022

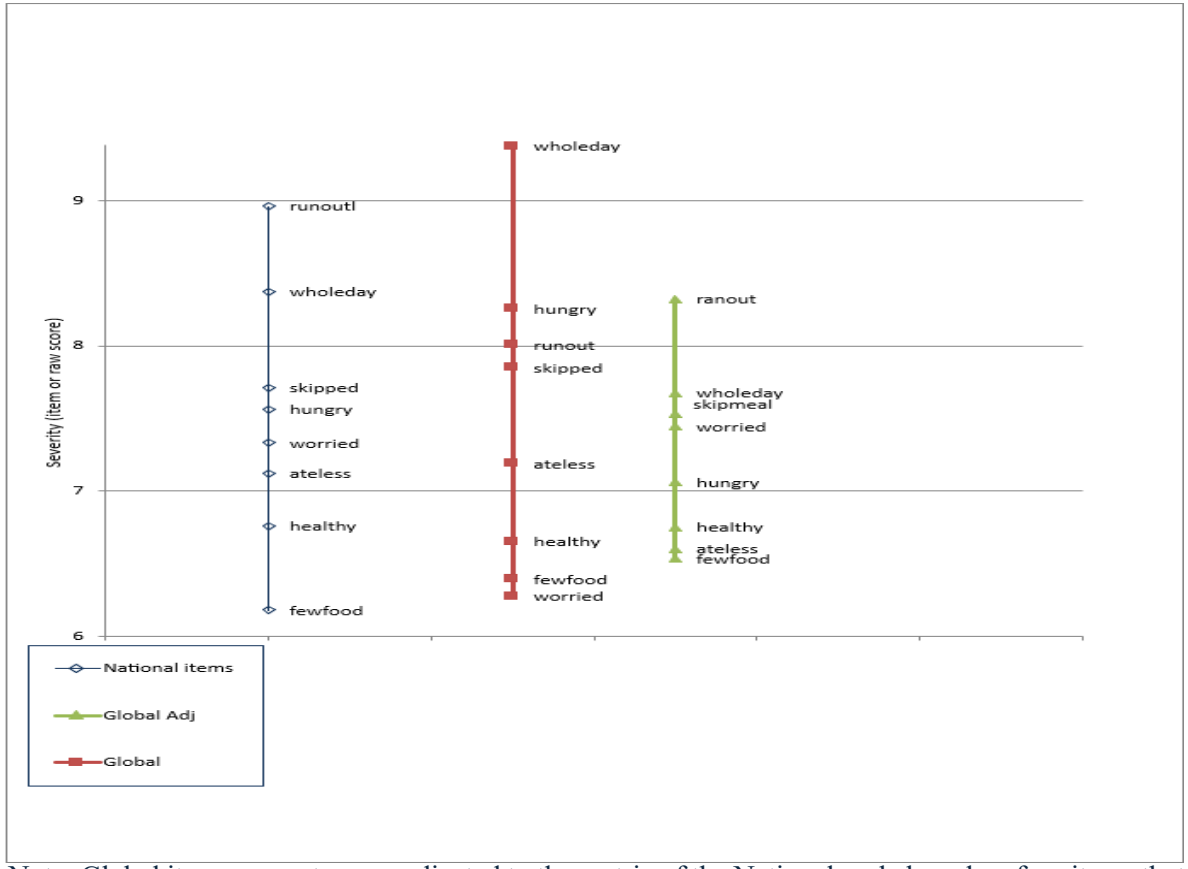
Note: Predicted probabilities for state dummies, and for SEIFA 4^{th}-9^{th} decile are not reported for brevity. Reference groups are denoted by (=0). [a]'Others' comprise the related family without children and non-family members. [b]Decile of Index of relative socio-economic disadvantage. [c]Phase 1 implies the first phase of interview carried out during August 1-mid October, and phase 2 denotes the next phase of interviews during mid-October-February '21.

Figure 1: Equating Plot: Global reference scale versus National scale



Note: Items which lie on the 45-degree line exhibit approximately equal severity (correlation between items: 99.4%). These four items (*healthy*, *ateless*, *hungry*, *wholeday*) form the metric adjustment set, mean and SD of these 4 items are used to equate the global and the national scales. *Estimated item severities of Global Reference Scale available at:* https://www.fao.org/in-action/voices-of-the-hungry/analyse-data/en/

Figure 2: Severities of Items: FIES National (2020) vs Global reference Scale



Note: Global item parameters are adjusted to the metric of the National scale based on four items that appear to be equivalent in the two scales: *healthy*, *ateless*, *hungry* and *wholeday*. Estimated item severities of Global Reference Scale available at: https://www.fao.org/in-action/voices-of-the-hungry/analyse-data/en/

References

1. Akbar, H., Radclyffe, C. J. T., Santos, D., Mopio-Jane, M., & Gallegos, D. (2022). “Food Is Our Love Language”: Using Talanoa to Conceptualize Food Security for the Māori and Pasifika Diaspora in South-East Queensland, Australia. *Nutrients*, *14*(10), 2020-. https://doi.org/10.3390/nu14102020
2. Archer, C., Gallegos, D., & McKechnie, R. (2017). Developing measures of food and nutrition security within an Australian context. *Public Health Nutrition*, *20*(14), 2513–2522. https://doi.org/10.1017/S1368980017001288
3. Australian Bureau of Statistics (ABS). (2023). *Personal income in Australia*. Available at: https://www.abs.gov.au/statistics/labour/earnings-and-working-conditions/personal-income-australia/2020-21-financial-year
4. Australian Bureau of Statistics (ABS). (2016). *2071.0 - Census of Population and Housing: Reflecting Australia - Stories from the Census*, 2016 Census of Population and Housing.
5. Australian Bureau of Statistics (ABS). (2015). National Health Survey 2011-2012. Canberra: ABS. Available at: www.abs.gov.au/AUSSTATS/abs@.nsf/DetailsPage/4364.0.55.0092011-12?OpenDocument
6. Ballard, T., Kepple, A. & Cafiero, C. (2013). *The food insecurity experience scale: development of a global standard for monitoring hunger worldwide*, Technical paper, FAO, Rome.
7. Ballard, Terri; Coates, Jennifer; Swindale, Anne; and Deitchler, Megan. (2011). *Household Hunger Scale: Indicator Definition and Measurement Guide*. Washington, DC: Food and Nutrition Technical Assistance II Project, FHI 360.
8. Barrett, C. B. (2002). Chapter 40 Food security and food assistance programs. In *Handbook of Agricultural Economics* (Vol. 2, pp. 2103–2190). Elsevier B.V. https://doi.org/10.1016/S1574-0072(02)10027-2
9. Behrman, J. R. (1993). Intra-Household Allocation of Nutrients and Gender Effects: A Survey of Structural and Reduced-Form Estimates. In *Nutrition and Poverty* (pp. 287–321). Oxford University Press. https://doi.org/10.1093/acprof:oso/9780198283966.003.0010
10. Bickel, G., M. Nord, C. Price, W. Hamilton, J. Cook (2000). *Guide to Measuring Household Food Security (revised)*. Alexandria, Va, USA, US Department of Agriculture, Food and Nutrition Service.
11. Bond, T., & Fox, C. M. (2015). *Applying the Rasch Model: Fundamental Measurement in the Human Sciences, Third Edition* (Third edition.). Routledge. https://doi.org/10.4324/9781315814698
12. Bowden, M. (2020). *Understanding food insecurity in Australia*, CFCA paper No. 55, Child Family Community Australia information exchange, Australian Institute of Family Studies, Victoria, Australia. Available at: https://aifs.gov.au/resources/policy-and-practice-papers/understanding-food-insecurity-australia.
13. Burchi, F., De Muro, P. (2012). *A human development and capability approach to food security: Conceptual framework and informational biases*. Tech. Rep. 9, UNDP, Washington D.C.
14. Burns, C., Bentley, R., Thornton, L., & Kavanagh, A. (2011). Reduced food access due to a lack of money, inability to lift and lack of access to a car for food shopping: a multilevel study in Melbourne, Victoria. *Public Health Nutrition*, 14(6), 1017–1023. https://doi.org/10.1017/S136898001000385X
15. Burns. C. (2004). *A review of the literature describing the link between poverty, food insecurity and obesity with specific reference to Australia.* Physical Activity Unit. Food Insecurity Program. Victorian Health Promotion Foundation.

16. Cafiero, C., Viviani, S., & Nord, M. (2018). Food security measurement in a global context: The food insecurity experience scale. *Measurement : Journal of the International Measurement Confederation*, *116*, 146–152. https://doi.org/10.1016/j.measurement.2017.10.065
17. Chilton, M., Knowles, M., & Bloom, S. (2017). The intergenerational circumstances of household food insecurity and adversity. *Journal of Hunger and Environmental Nutrition*, 12(2), 269-297.
18. Coates, J., Swindale, A., & Bilinsky, P. (2007). *Household Food Insecurity Access Scale (HFIAS) for measurement of household food access: indicator guide* (v. 3). Food and Nutrition Technical Assistance Project, Academy.
19. Coates, J., Wilde, P.E., Webb, B., Rogers, L. & Houser, R.F. (2006). Comparison of a qualitative and a quantitative approach to developing a household food insecurity scale for Bangladesh. *Journal of Nutrition*, 136: 1420S-1430S.
20. Coleman-Jensen, Alisha, Matthew P. Rabbitt, Christian A. Gregory, Anita Singh. (2022). *Household Food Security in the United States in 2021*, ERR-309, U.S. Department of Agriculture, Economic Research Service.
21. Cook, J. T., & Frank, D. A. (2008). Food Security, Poverty, and Human Development in the United States. *Annals of the New York Academy of Sciences*, *1136*(1), 193–209. https://doi.org/10.1196/annals.1425.001
22. Cunningham, J., & Paradies, Y. C. (2012). Socio-demographic factors and psychological distress in Indigenous and non-Indigenous Australian adults aged 18-64 years: analysis of national survey data. BMC Public Health, 12(1), 95–95. https://doi.org/10.1186/1471-2458-12-95.
23. Department of Foreign Affairs & Trade (DFAT) (n.d.). 2030 Agenda for Sustainable Development and the Sustainable Development Goals, Available at: https://www.dfat.gov.au/aid/topics/development-issues/2030-agenda-sustainable-development. Accessed July 1, 2024.
24. Food and Agriculture Organization of the United Nations (FAO). (n.d.). *Voices of the Hungry. The Food Insecurity Experience Scale. One metric for the world*. Available at: https://www.fao.org/in-action/voices-of-the-hungry/analyse-data/en/
25. FAO, IFAD, UNICEF, WFP and WHO. (2023). *The State of Food Security and Nutrition in the World 2023. Urbanization, agrifood systems transformation and healthy diets across the rural–urban continuum*. Rome, FAO. https://doi.org/10.4060/cc3017en.
26. FAO, IFAD, UNICEF, WFP and WHO (2021). *The State of Food Security and Nutrition in the World 2021: Transforming food systems for food security, improved nutrition and affordable healthy diets for all*, FAO, Rome.
27. FAO, IFAD, UNICEF, WFP and WHO (2018). *The State of Food Security and Nutrition in the World 2018: Building climate resilience for food security and nutrition,* FAO, Rome.
28. FAO (1996). *Rome Declaration on World Food Security and World Food Summit Plan of Action*, World Food Summit, 13-17 November 1996, Rome, Italy.
29. Foley, W., Ward, P., Carter, P., Coveney, J., Tsourtos, G., & Taylor, A. (2010). An ecological analysis of factors associated with food insecurity in South Australia, 2002–7. *Public Health Nutrition*, 13(2), 215–221. https://doi.org/10.1017/S1368980009990747.
30. Friel, S., Berry, H., Dinh, H., O'Brien, L., & Walls, H. L. (2014). The impact of drought on the association between food security and mental health in a nationally representative Australian sample. *BMC Public Health*, 14(1), 1102–1102. https://doi.org/10.1186/1471-2458-14-1102
31. Gallegos, D., Ramsey, R., & Ong, K. W. (2014). Food insecurity: is it an issue among tertiary students? *Higher Education*, *67*(5), 497–510. https://doi.org/10.1007/s10734-013-9656-2
32. Gary King and Jonathan Wand. (2007). Comparing Incomparable Survey Responses: New Tools for Anchoring Vignettes. *Political Analysis*, 15, Pp. 46-66.
33. Godrich, S., Lo, J., Davies, C., Darby, J., & Devine, A. (2017). Prevalence and socio-demographic predictors of food insecurity among regional and remote Western Australian children. *Australian and New Zealand Journal of Public Health*, 41(6), 585–590. https://doi.org/10.1111/1753-6405.12716

34. Gray, M., & Smart, D. (2009). Growing Up in Australia: The Longitudinal Study of Australian Children. A valuable new data source for economists. *Australian Economic Review*, 42(3), 367-376.
35. Haddad, L., Kennedy, E., Sullivan, J. (1994). Choice of Indicators for Food Security and Nutrition Monitoring. *Food Policy*. 19(3): 329-343
36. Hamilton, W. L., Cook, J.T., Thompson, W.W., Buron, L.*F., Frongillo, E.A. Jr., Olson, C.M., & Wehler, C.A. (1997). Household Food Security in the United States in 1995: Technical Report,* prepared for the U.S. Department of Agriculture, Food and Consumer Service, Washington, DC.
37. Herault, N & Ribar, DC. (2017)., 'Food insecurity and homelessness in the Journeys Home survey', *Journal of Housing Economics*, vol. 37, pp. 52–66, doi: 10.1016/j.jhe.2017.05.001.
38. Jun, S., Cowan, A. E., Dodd, K. W., Tooze, J. A., Gahche, J. J., Eicher-Miller, H. A., Guenther, P. M., Dwyer, J. T., Potischman, N., Bhadra, A., Forman, M. R., & Bailey, R. L. (2021). Association of food insecurity with dietary intakes and nutritional biomarkers among US children, National Health and Nutrition Examination Survey (NHANES) 2011–2016. *The American Journal of Clinical Nutrition*, *114*(3), 1059–1069. https://doi.org/10.1093/ajcn/nqab113
39. Kent, K., Murray, S., Penrose, B., Auckland, S., Horton, E., Lester, E., & Visentin, D. (2022). The new normal for food insecurity? A repeated cross-sectional survey over 1 year during the COVID-19 pandemic in Australia. *The International Journal of Behavioral Nutrition and Physical Activity*, *19*(1), 1–115. https://doi.org/10.1186/s12966-022-01347-4
40. Kleve, S., Davidson, Z. E., Gearon, E., Booth, S., & Palermo, C. (2017). Are low-to-middle-income households experiencing food insecurity in Victoria, Australia? An examination of the Victorian Population Health Survey, 2006-2009. *Australian Journal of Primary Health*, *23*(3), 249–256. https://doi.org/10.1071/PY16082
41. Knowles, M., Rabinowich, J., De Cuba, S., Cutts, D., & Chilton, M. (2016). Do you wanna breathe or eat?": Parent perspectives on child health consequences of food insecurity, trade-offs, and toxic stress. *Maternal and Child Health Journal*, 20(1), 25-32.
42. Law, I., Ward, P. R., & Coveney, J. D. (2011). Food insecurity in South Australian single parents: An assessment of the livelihood's framework approach. *Critical Public Health*, 21(4), 455-469
43. Lawlis, T., Islam, W., & Upton, P. (2018). Achieving the four dimensions of food security for resettled refugees in Australia: A systematic review. *Nutrition & Dietetics*, 75, 182-192.
44. McKechnie, R., Turrell, G., Giskes, K., & Gallegos, D. (2018). Single-item measure of food insecurity used in the National Health Survey may underestimate prevalence in Australia. *Australian and New Zealand Journal of Public Health*, *42*(4), 389–395. https://doi.org/10.1111/1753-6405.12812
45. Maitra, C., & Rao, D. S. P. (2015). Poverty–Food Security Nexus: Evidence from a Survey of Urban Slum Dwellers in Kolkata. *World Development*, *72*, 308–325. https://doi.org/10.1016/j.worlddev.2015.03.006
46. National Sample Survey Organisation (NSSO). (1993-94). *Reported Adequacy of Food Intake in India*. New Delhi, India, Report No. 415, 50th Round, July 1993 - June 1994, National Sample Survey Organisation, Department of Statistics, Government of India.
47. Nord, M. (2012). *Assessing potential technical enhancements to the U.S. Household Food Security Measures*. Technical Bulletin 1936, December. Washington DC, USDA/ERS.
48. Nord, M., A.K. Satpathy, N. Raj, P. Webb and R. Houser (2002). *Comparing Household Survey-Based Measures of Food Insecurity Across Countries: Case Studies in India, Uganda and Bangladesh*. Discussion Paper No 7, Friedman School of Nutrition Science and Policy, Tufts University.
49. Parliament of Australia (2023). *Australian Food Story: Feeding the Nation and Beyond.* Inquiry into food security in Australia. House of Representatives Standing Committee on Agriculture. Canberra.

50. Pérez-Escamilla, R. (2012). Can experience-based household food security scales help improve food security governance? *Global Food Security*, *1*(2), 120–125. https://doi.org/10.1016/j.gfs.2012.10.006
51. Pérez-Escamilla, R., Melgar-Quiñonez, H., Nord, M., Alvarez Uribe, M.C. & Segall-Correa, A.M. (2007). *Escala Latinoamericana y Caribeña de Seguridad Alimentaria (ELCSA) [Latinamerican and Caribbean Food Security Scale*]. *Perspectivas en Nutrición Humana, Colombia. 2007(supplement*):117-134
52. Pollard, C. M., Savage, V., Landrigan, T., Hanbury, A., & Kerr, D. (2015). *Food Access and Cost Survey*, Department of Health, Perth, Western Australia. Perth: Department of Health. Retrieved from www.health.wa.gov.au/~/media/Files/Corporate/Reports%20and%20publications/Chronic%20Disease/Food-Access-and-Cost-Survey-Report-2013-Report.pdf.
53. Quine, S., & Morrell, S. (2006). Food insecurity in community-dwelling older Australians. *Public Health Nutrition*, *9*(2), 219–224. https://doi.org/10.1079/PHN2005834
54. Radimer, K. L., Olson, C.M and C. C. Campbell (1990). Development of Indicators to Assess Hunger. *The Journal of Nutrition*, 120: 1544–1548.
55. Rogers, A. M., Lauren, B. N., Woo Baidal, J. A., Ozanne, E. M., & Hur, C. (2021). Persistent effects of the COVID-19 pandemic on diet, exercise, risk for food insecurity, and quality of life: A longitudinal study among U.S. adults. *Appetite*, *167*, 105639–105639. https://doi.org/10.1016/j.appet.2021.105639
56. Rogers, A., Ferguson, M., Ritchie, J., Van Den Boogaard, C., & Brimblecombe, J. (2018). Strengthening food systems with remote Indigenous Australians: Stakeholders' perspectives. *Health Promotion International*, 33, 38-48.
57. Rose, D. (1999). Economic determinants and dietary consequences of food insecurity in the United States. *The Journal of Nutrition*, 129(2), 517S-520S. https://doi.org/10.1093/jn/129.2.517s.
58. Schwartz, N., Buliung, R., & Wilson, K. (2019). Disability and food access and insecurity: A scoping review of the literature. *Health and Place*, 57, 107-121.
59. Temple, J. B. (2018). The association between stressful events and food insecurity: Cross-sectional evidence from Australia. *International Journal of Environmental Research and Public Health*, 15, 2333.
60. Temple, J. B. (2006). Food insecurity among older Australians: prevalence, correlates, and well-being. *Australasian Journal on Ageing*, *25*(3), 158–163. https://doi.org/10.1111/j.1741-6612.2006.00172.x
61. Temple, J. B., Booth, S., Pollard, C. M. (2019). Social assistance payments and food insecurity in Australia: Evidence from the Household Expenditure Survey. *International Journal of Environmental Research and Public Health*, 16, 455.
62. Vandenberg, M., & Galvin, L. (2016). *Dishing up the facts: Going without healthy food in Tasmania*. Retrieved from www.healthyfoodaccesstasmania.org.au/wp-content/uploads/2016/07/Dishing-up-the-facts-July2016.pdf
63. Wooden, M., Bevitt, A., Chigavazira, A., Greer, N., Johnson, G., Killackey, E., Moschion, J., Scutella, R., Tseng, Y.-P., & Watson, N. (2012). Introducing "Journeys Home." *Australian Economic Review*, *45*(3), 368–378. https://doi.org/10.1111/j.1467-8462.2012.00690.x
64. Wynn, Katherine; Goessler, Callum; Jarrett, Lisa; Liu, Mingji; McClure, Erin; Sperling, Frank; Thomas, Laura. (2023). *Reshaping Australian Food Systems.* Canberra: CSIRO. csiro:EP2023-2170. https://doi.org/10.25919/d5ft-a477

Appendix A

Table A1: Summary of the selected literature on experiential food insecurity measures in Australia.

Survey year	Author(s)/publication year	Survey & study population	Study population	Setting	Sample size	FI indicator	Prevalence of FI (%)	Level of measure
1995	Temple, 2008	National Nutrition Survey	General population	National	11291	Single item with a follow up question: Respondents answering yes to question on running out of food and being unable to afford to buy any more in the past 12 months	5.1	HH
2001		National Nutrition Survey	General population	National	17918	Same as above	5.2	HH
2005		National Nutrition Survey	General population	National	19501	Same as above	5.1	HH
		Food Depletion Only "Moderate"	General population	National		Respondents answering "no" to the follow up question on running out of food went without food when food ran out and unable to afford to buy any more food	3.1	HH
		Inadequate Intake "Severe"	General population	National		Respondents answering "yes" to the above follow up question.	2.0	HH
1998/99		Household Expenditure Survey	General population	National	6892	respondent who answered "yes" to the "question on anyone in the HH (including the respondent) going without meals over the past 12 months because of a shortage of money	2.7	HH
2002		General Social Survey	General population	National	15510	Same as above	1.9	HH

2003/04		Household Expenditure Survey4	General public	National	6957	Same as above	3.1	HH
2004	(Nolan et al., 2006)	Independent primary survey	Adults >18 years	three disadvantaged locations of south-western Sydney	1719	Muti-item:16-item US tool	21.9 [FI without hunger: 14.0, FI with moderate hunger:6.1, FI with severe hunger:1.8]	HH
2004	(Nolan et al., 2006)	Independent primary survey	Adults >18 years	three disadvantaged locations of south-western Sydney	1719	Singel item: AHS 20211/13 measure (food running out)	15.8	HH
2003	(Burns, Bentley, Thornton, & Kavanagh, 2010)	Independent Survey	General population	Melbourne	2564	Single items: three measures of restricted food access: running out of money to buy food, inability to lift groceries and lack of access to a car for food shopping	8.1%	HH
2004-05	(Cunningham & Paradies, 2012)	National Aboriginal and Torres Strait Islander Health Survey (NATSIHS) and the NHS	First Nations people, 18-64 years	Australia	5,417 Indigenous	Single item: running out of food	24.6	HH
2006–09	(Kleve et al., 2017)	Victorian Population Health Surveys (VPHS).	General population	Victoria	n = 7543 in 2006, n = 7604 in 2007, n = 34 169 in 2008 and n = 7740 in 2009	Single item with a follow up question: running out of food and unable to afford to buy more	4.9 and 5.5% for total survey populations and 3.9–4.8% in low-to-middle-income respondents	HH
2002-2007	(Foley et al., 2010)	South Australian Monitoring and Surveillance System (SAMSS),	General population	South Australia	19307	Single item: running out of food during the previous year and not having enough money to buy food	7	HH
2007-08	(Friel, Berry, Dinh, O'Brien, & Walls, 2014)	HILDA, Australian Bureau of Meteorology	General population (>15 years)	Australia	5012	Single Item: those who reported missing meals due to financial stress	1.6	HH
2009	(Gallegos, Ramsey, & Ong, 2014)	Web-based survey,	mostly young females – university students	Brisbane, Queensland	810	Muti-item: 18-item USDA 12-month reference	25.5	HH

2012	(Gichunge, Harris, Tubei, Somerset, & Lee, 2015)	Independent survey	Refugees, mostly children and females	Southeast Queensland	383	Multi-item: 18-item USDA 6-month reference	18	HH
?	(Godrich, Lo, Davies, Darby, & Devine, 2017)	Independent Survey	Mostly female school children and female care givers	Western Australia	438	Multi-item: Child Food Security Survey Module (CFSSM)	20.1	HH
1999–2000	(Quine & Morrell, 2006)	computer-assisted telephone interview	Older people aged over 65 years and living independently	NSW	8881	Single item: running out of food in the last 12 months and being unable to afford to buy more	2%	HH
2001	(Temple, 2006)	NHS	Older Australians: >55 years	Australia	4650	Single item: NHS measure on running out of food	2.80	HH
2009	McKechnie et al. (2018)	independent postal survey	Individuals aged ≥18 years	disadvantaged suburbs of Brisbane city	505	Single item NHS measure,	19.5	HH
						Multi-item: 18-item versions of the USDA-FSSM	24.4	HH
						Muti-item: 10-item versions of the USDA-FSSM	22.8	HH
						6-item versions of the USDA-FSSM	21.1	HH
2012-2013	(Temple & Russell, 2018)	2012–2013 Australian Aboriginal and Torres Strait Islander & Nutrition and Physical Activity Survey (NATSINPAS)	Older aboriginal adults: >55 years	Australia	1062	Single item: NHS measure based on running out of food, and the follow up question on going without meals in the past 12 months	21 (FI), 40 (FI with food depletion and inadequate intake),	HH
2015-16	(Temple, Booth, & Pollard, 2019)	Household Expenditure Survey (HES)	General population	National	Approx. 10000	Single item measure on going without meals	2.8	HH
2013	(Herault & Ribar, 2017)	Journeys Home Survey (Wave 5)	Homeless people	National	1210 observations: 642 men and 568 women.	Muti-item: Household Food Insecurity Access Scale (HFIAS) - six of the nine questions		HH
May 2020, September	(Kent et al., 2022)	online surveys using convenience sampling methods,	Adult population	Tasmania	during lockdown (n= 1168), 1	Muti-item: US HFSSM: Six-Item Short Form	27.9% during lockdown, 19.5% when restrictions had eased	HH

2020, May 2021					when restrictions had eased (n= 1097), 1-year post-lockdown (n= 1100).		and 22.6% 1-year post-lockdown	
2020	Botha et al., 2024	HILDA Survey	Adults (>15 years)	National	14971	Multi-item: Eight-item FIES	Individual FI :9%	Individual

Table A2: Item parameters of the 8 FIES items (FAO global scale 2014-2016) versus National Scale

	Item severities[a]							
			Absolute difference between country and standard item severities (after calibration)					
Items (1)	National (2)	Global (before standardization) (3)	Using all 8 items (4)	Omitting runout (5)	Omitting worried (6)	Omitting skipmeal (7)	Omitting fewfood (8)	Global standardized (9)
Worried	6.83	5.78	0.83	0.75	0.97	1.00	0.79	6.04
Healthy	6.26	6.15	0.04	0.05	0.14	0.18	0.01	6.25
Fewfood	5.68	5.89	0.41	0.47	0.25	0.23	0.42	6.10
Skipmeal	7.21	7.35	0.07	0.16	0.27	0.33	0.27	6.94
Ateless	6.62	6.69	0.13	0.03	0.13	0.18	0.06	6.56
Runout	8.46	7.51	1.04	1.31	1.41	1.47	1.43	7.03
Hungry	7.06	7.75	0.56	0.24	0.16	0.09	0.11	7.18
Wholeday	7.87	8.88	0.67	0.13	0.13	0.04	0.05	7.82
Correlations between common items			74.72%	85.09%	96.35%	97.77%	99.38%	

Note: [a]Item severity parameters in food security measurement vary as to the severity of food insecurity to which they are sensitive. Reported item severities have been obtained by adding seven to severity parameters reported by the softwares (see Bickel et al., 2000). To equate the two scales, the highlighted items are omitted as they exhibit DIF. The remaining four items *healthy*, *ateless*, *hungry*, *wholeday* show approximately equal severity in the two surveys (item correlation increases to 99.4%). These four items form the metric adjustment set. Mean and SD of these items are used to equate the two scales. Col. 8 reports the absolute difference between country and standard item severities (after calibration). Item severities of the standardized global scale (after calibration) is reported in Col.9.

Table A3: Probabilistic assignment to food security categories using comparable thresholds for the *global* reference scale & the *national* scale

Raw score	Severity[a]	Error	No. of cases (N=14971)	Percentage of individuals	Probability (mod+sev)	Probability (sev)
0	4.02	1.49	12855	85.9%	0	0
1	4.82	1.10	682	4.6%	0.057374	0.003247
2	5.74	0.86	357	2.4%	0.170612	0.007776
3	6.40	0.78	249	1.7%	0.420099	0.034295
4	6.99	0.76	172	1.1%	0.713958	0.136379
5	7.58	0.78	161	1.1%	0.903145	0.378372
6	8.25	0.87	166	1.1%	0.974283	0.689626
7	9.19	1.11	146	1.0%	0.990995	0.890736
8	10.21	1.49	183	1.2%	0.993001	0.946037

Note: [a] These severity parameters are continuous interval-level measures of the extent of food insecurity or hunger for the individual. The zero point on the Rasch Scale is arbitrary. Reported scale severities have been obtained by adding seven to severity parameters reported by the software (see Bickel et al., 2000). The severity of food insecurity with raw score zero and eight is unknown. The tables for raw score 8 was calculated as if for raw score 7.5. VoH (FAO, n.d.) methodology entails assigning a probability of belonging to each of the food insecurity classes (*mode+sev* and *severe*) to each respondent, based on the reported raw score and the estimated severity level and standard error of that raw score. Results are obtained using FIES app available at: https://www.fao.org/in-action/voices-of-the-hungry/analyse-data/en/ . Global scale is standardized using the mean and SD of the common items in both surveys: *healthy*, *ateless*, *hungry*, *wholeday* (standardized reported in table A2). Prevalence estimates for *mod+sev* FI (6.42%) and *severe* FI (3.44%) are obtained using the adjusted "true" severity of common thresholds *ateless* (*6.56*) and *wholeday* (*7.82*), respectively. For detailed methodology, see FAO (n.d.).

Table A4: Item severity parameters, estimation of Rasch model across Australian States, 2020

Item	NSW	VIC	QLD	SA	WA	TAS	ACT
Worried	6.89 (0.11)	6.62(0.12)	6.84 (0.11)	6.92 (0.18)	6.94 (0.21)	6.99 (0.30)	7.84(0.63)
Healthy	6.10 (0.10)	6.29 (0.11	6.28 (0.11)	6.59 (0.18)	6.26 (0.19)	6.39 (0.29)	7.98 (0.48)
Fewfood	5.53(0.10)	5.61 (0.11)	5.81 (.10)	5.74 (0.17)	5.58 (0.19)	6.32 (0.29)	8.04 (0.48)
Skipped	7.28 (.12)	7.33 (0.13)	7.10 (.12)	7.13 (0.19)	7.17 (0.21)	7.07 (0.30)	7.79 (0.69)
AteLess	6.60 (.11)	6.65 (0.12)	6.64 (0.11)	6.54 (0.18)	6.52 (0.20)	6.69 (0.29)	7.84 (0.59)
RunOut	8.45 (.14)	8.58 (0.16)	8.48 (0.15)	8.36 (0.22)	8.33 (0.25)	8.22 (0.35)	8.35 (0.91)
Hungry	7.09 (.11)	7.10 (0.12)	7.13 (0.12)	6.84 (0.18)	7.02 (0.21)	6.91(0.30)	7.90 (0.61)
WholeDay	8.05 (.13)	7.82 (0.14)	7.70 (0.13)	7.89 (0.20)	8.18 (0.24)	7.40 (0.31)	8.34 (1.16)
Conditional log-likelihood	-1336.83	-1157.56	-1328.13	-511.34	-403.28	-195.13	-44.86
N	529	425	502	189	160	70	22
Missing	2321	1914	1893	663	703	259	144
Extreme responses	3699	3458	2764	1132	1184	459	290

Note: Estimation method: Conditional Maximum Likelihood. Number of Items: 8. No. of groups: 9 (7 of them are used to compute the statistics of test). Reported item severities have been obtained by adding seven to severity parameters reported by Stata. Observations with missing responses are removed. Number of responses with null or perfect score are omitted from the psychometric analysis.

Table A5: Item fit statistics : Estimation of Rasch model across States, 2020

	NSW(N=529)		VIC(N=425)		QLD (N=502)		SA (N=189)		WA (N=160)		TAS (N=70)		ACT (N=22)	
Item	**Infit**	**Outfit**	**Infit**	**Outfit**	**Infit**	**Outfit**	**Outfit**	**Infit**	**Infit**	**Outfit**	**Infit**	**Outfit**	**Infit**	**Outfit**
fewfood	0.99	0.96	1.08	1.19	0.91	0.86	1.13	1.17	1.08	1.08	0.84	0.77	1.00	1.34
healthy	1.21	1.22	1.25	1.38	1.21	1.25	1.31	1.43	1.21	1.27	0.98	0.90	0.72	0.64
ateless	1.06	1.17	1.03	1.24	1.08	1.31	1.05	0.98	1.01	0.93	1.04	0.98	1.04	1.34
worried	0.79	0.69	0.75	0.62	0.73	0.62	0.72	0.62	0.80	0.69	0.79	0.76	0.74	0.37
hungry	0.94	0.87	0.90	0.85	0.83	0.75	0.75	0.67	0.80	0.70	0.84	0.76	0.75	0.75
skipmeal	1.05	1.17	0.97	0.73	0.99	1.11	1.03	0.98	1.13	1.06	1.35	1.40	0.58	0.18
wholeday	0.83	0.72	0.92	0.83	0.92	0.87	0.81	0.7	0.84	0.83	0.90	0.82	1.40	1.62
ranout	1.17	1.17	1.07	0.96	1.31	1.52	1.21	1.56	1.22	1.21	1.34	1.65	1.66	6.53

Note: Estimation method: Conditional Maximum Likelihood. Number of Items: 8. No. of groups: 9 (7 of them are used to compute the statistics of test). Reported item severities have been obtained by adding seven to severity parameters reported by Stata. ·Infits in the range of 0.7–1.3 are acceptable (Nord et al., 2002).

Table A6: FIES-based Food Security Status across Selected Socio-Economic & Demographic Characteristics: Australia 2020

Socio-economic/demographic characteristics	Mean	Highly FS (%) (N= 12,855)	Marginally FS (%) (N=683)	Moderately FI (%) (N=1105)	Severely FI (%) (N=329)
Highest education level achieved					
< year 11 (==0)	21.81	82.86	5.40	8.70	3.03
bachelor's degree or above	30.82	92.38	3.39	3.76	0.47
completed high school but below bachelor's degree	47.37	84.41	4.07	8.85	2.66
Remoteness Area					
major cities (=0)	72.32	87.39	3.97	6.85	1.78
outer regional/remote	8.74	84.53	5.43	7.66	2.37
inner regional	18.94	86.50	4.17	7.25	2.09
Aboriginal or Torres Strait Islander origin					
not indigenous (=0)	96.95	87.21	4.00	6.84	1.95
indigenous	3.05	68.09	6.18	18.78	6.96
Marital status					
never married (=0)	25.68	81.85	4.37	9.98	3.80
married	61.78	90.41	3.63	5.02	0.94
separated or divorced	8.42	77.65	6.10	12.64	3.61
widowed	4.11	86.18	6.23	6.63	0.97
Current labour force status					
Employed (=0)	61.47	89.59	3.58	5.72	1.11
unemployed	4.03	70.55	6.02	17.49	5.94
not in the labor force	34.51	82.78	5.02	8.84	3.36
Long term health condition					
no (=)	70.34	89.53	3.75	5.57	1.15
yes	29.66	78.93	5.23	11.46	4.37
Age group					

<20 (=0)	7.3	86.10	4.19	7.22	2.49
20-30	17.96	82.50	3.65	10.40	3.44
35-45	18.7	84.81	5.26	7.54	2.38
45-60	26.43	86.29	3.87	7.77	2.06
60-70	14.79	90.20	3.55	5.29	0.96
>=70	14.83	91.26	5.32	3.25	0.17
Sex					
Male (=0)	46.77	88.03	3.89	6.16	1.92
female	53.23	86.02	4.34	7.74	1.89
Family type					
lone persons (=0)	12.74	79.53	6.71	9.98	3.79
couple family without children	28.36	91.46	3.44	4.32	0.77
couple family with dependent children	35.2	89.29	3.75	5.58	1.38
couple with no dep children	9.94	92.12	2.55	4.60	0.73
lone parent with dependent children	5.72	70.34	5.94	19.02	4.69
lone parent with no dep children	5.31	78.84	5.81	11.86	3.49
Others[a]	2.73	76.61	3.01	13.51	6.86
Income deciles					
Bottom 10%	8.69	73.94	7.17	13.26	5.63
2nd decile	9.26	76.07	7.87	11.86	4.20
3rd decile	9.04	80.69	5.28	10.49	3.54
4th decile	9.45	83.44	4.42	9.90	2.25
5th decile	10.18	85.79	4.74	8.31	1.15
6th decile	10.36	89.29	3.85	5.70	1.17
7th decile	10.88	92.23	2.96	3.83	0.99
8th decile	11.07	93.51	2.34	3.45	0.70
9th decile	10.31	92.65	2.70	4.45	0.20
top 10% (=0)	10.76	96.55	1.37	1.64	0.44
SEIFA 2001[b]					

lowest decile	10.27	79.87	5.16	10.35	4.63
2nd decile	8.28	80.63	5.21	10.49	3.67
3rd decile	9.43	82.61	5.79	9.73	1.87
4th decile	9.64	83.02	5.65	9.01	2.33
5th decile	8.77	85.66	3.32	9.55	1.47
6th decile	10.05	87.95	4.47	6.12	1.46
7th decile	10.92	88.58	2.93	6.77	1.73
8th decile	11.23	92.92	3.20	3.15	0.74
9th decile	11.04	92.33	3.40	3.12	1.10
top 10% (=0)	10.38	92.85	3.02	3.41	0.72
Time[c]					
Phase 1 of interview: strict lockdown period	93.86	80.41	4.06	10.79	4.73
Phase 2 of interview: restrictions relaxing (=0)	6.14	87.39	4.14	6.76	1.72

Note: Reference groups are denoted by (=0). [a]'Others' comprise the related family without children and non-family members. [b]Decile of Index of relative socio-economic disadvantage. [c]Phase 1 implies the first phase of interview carried out during August 1-mid October, and phase 2 denotes the next phase of interviews during mid-October-February '21.

Table A7: Marginal effects of Factors affecting Food Security Status, Ordered Probit Model: Australia 2020

	Food Secure (N= 12,855)	**Moderate FI (N=1105)**	**Severe FI (N=329)**
Bachelor's degree or higher	0.044*** (0.008)	-0.032*** (0.006)	-0.013*** (0.002)
High school	-0.005 (0.007)	0.004 (0.005)	0.002 (0.002)
Lowest 40% income	-0.059*** (0.007)	0.041*** (0.005)	0.017*** (0.002)
Outer regional/remote	0.008 (0.008)	-0.005 (0.006)	-0.002 (0.003)
Inner regional	0.011* (0.006)	-0.007* (0.004)	-0.003* (0.002)
Kids	0.009* (0.005)	-0.006* (0.003)	-0.003* (0.002)
SEIFA: lowest decile	-0.043** (0.014)	0.030** (0.010)	0.014** (0.004)
2nd decile	-0.031** (0.013)	0.021** (0.009)	0.009** (0.004)
3rd decile	-0.021* (0.012)	0.015* (0.009)	0.006* (0.004)
Indigenous	-0.043*** (0.014)	0.028*** (0.009)	0.014***(0.005)
Married	-0.029** (0.012)	0.020**(0.008)	0.009**(0.004)
Divorced/separated	-0.027**(0.010)	0.018**(0.007)	0.009**(0.003)
Widowed	-0.001(0.014)	0.001(0.010)	0.000(0.004)
Unemployed	-0.069***(0.013)	0.047***(0.008)	0.022***(0.005)
Not in the labor force	-0.041***(0.007)	0.029***(0.005)	0.013***(0.002)
Long term health condition	-0.084***(0.007)	0.058***(0.005)	0.027***(0.003)
20-30 years	-0.040**(0.017)	0.024**(0.011)	0.015**(0.006)
30-45 years	-0.012(0.020)	0.007(0.012)	0.004(0.007)
45-60 years	0.029*(0.018)	-0.019*(0.012)	-0.010*(0.007)
60-70 years	0.095***(0.018)	-0.066***(0.011)	-0.029***(0.006)
70 years and above	0.126***(0.017)	-0.091***(0.011)	-0.035***(0.006)
Females	-0.011**(0.005)	0.008**(0.004)	0.003**(0.002)
Couple family without children	0.078**(0.023)	-0.054**(0.016)	-0.024**(0.008)
Couple family with dep children	0.068**(0.027)	-0.047**(0.018)	-0.021**(0.009)
Couple family with no dep children	0.062**(0.028)	-0.043**(0.019)	-0.019**(0.009)
Lone parent with dep children	-0.002 (0.023)	0.001(0.015)	0.001(0.008)

Lone parent with no dep children	0.000 (0.023)	0.000 (0.015)	0.000 (0.008)
Others[a]	-0.043 (0.027)	0.027 (0.017)	0.016 (0.010)
Phase 1: strict lockdown period[b]	0.024** (0.011)	-0.016**(0.007)	-0.008**(0.004)
Note: ***, ** and * denote statistical significance at 1%, 5% and 10% level of significance, respectively. Standard errors in parenthesis. Marginal effects of state dummies, and for SEIFA 4th-9th decile are not reported for brevity. [a]'Others' comprise the related family without children and non-family members. [b]Phase 1 implies the first phase of interview carried out during August 1-mid October),and phase 2 denotes the next phase of interviews when restrictions were easing (mid-October-February '21). Following are the reference groups for categorical variables: income (top 60% of income distribution), education (<year 11), remoteness area (cities), index of relative socio-economic disadvantage (top 10%), marital status (never married), long term health condition (those who say no), age group (<20 years), labor force status (employed), sex (male), family type (lone persons), time (phase 2: restrictions easing).			

Figure A1: Item-Raw score Map: Severities of Items and Raw Scores, FIES Australia, 2020

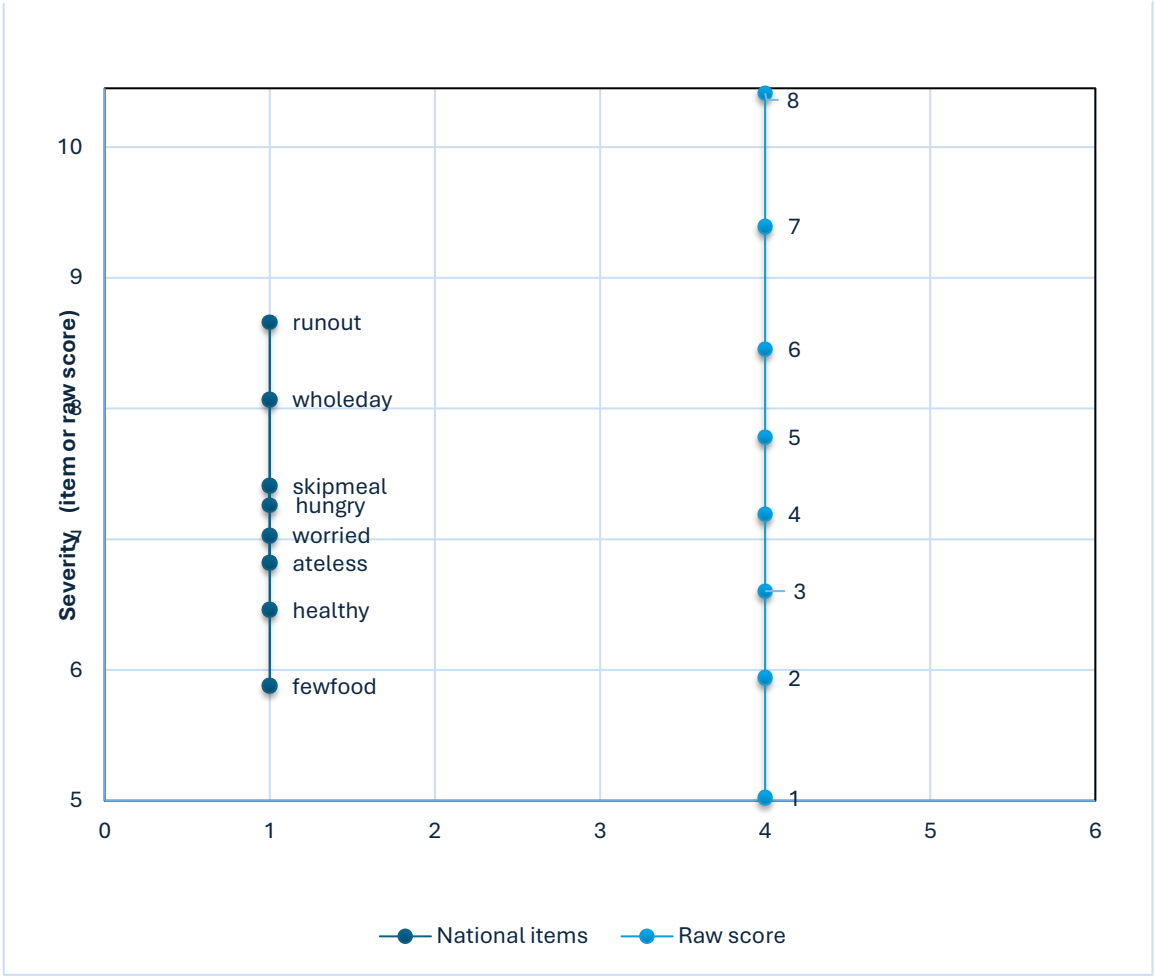
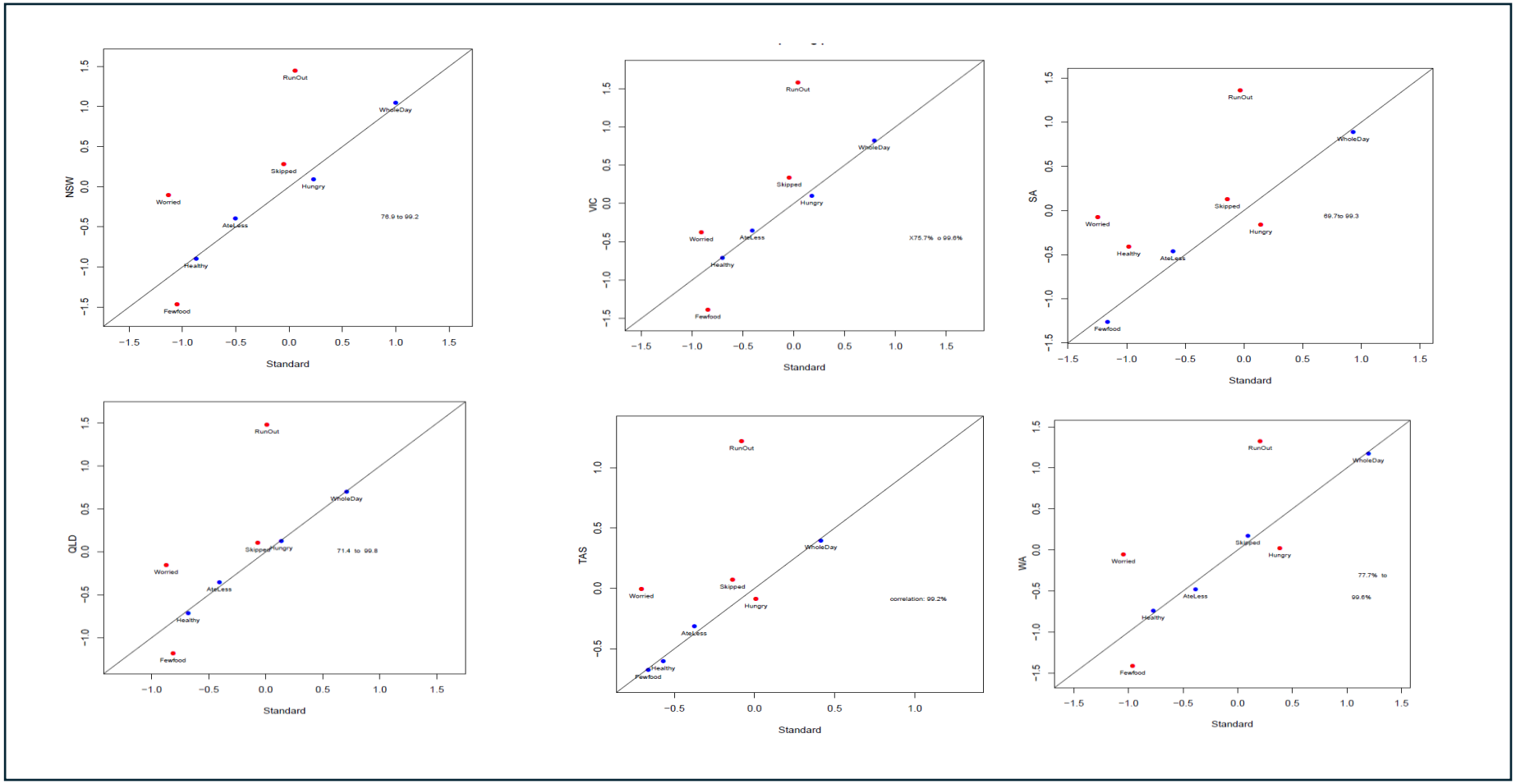
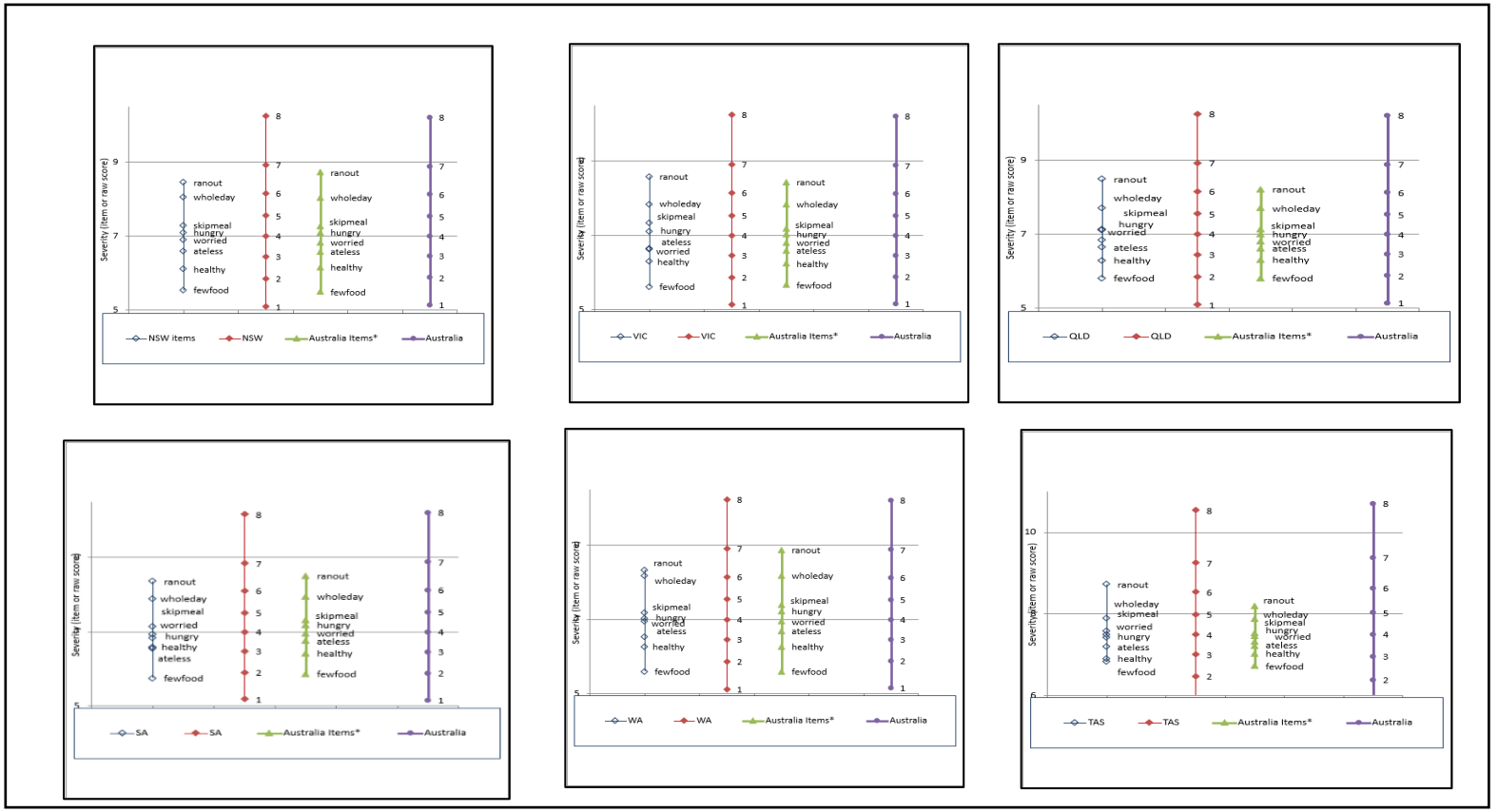


Figure A2: Equating plots: Global Reference Scale (Standard) versus Australian states



Note: Blue dots indicate items in the metric adjustment set, which have almost equal severity in *State* versus *Global* Rerence scales. Equating plot could not be generated for NT and ACT due to small samples. Items *worried*, *skipmeal* and *runout* exhibit DIF in all states except WA. Additionally, DIF is detected for *fewfood* in NSW, VIC and QLD, *healthy* and *hungry* in SA, *hungry* in TAS. In WA, items *worried, runout, fewfood* & *hungry* exhibit DIF.

Figure A3: Severities of items and raw scores: National Reference Scale versus State-specific Scales



Note: National item parameters and respondent severity measures were adjusted to the metric of the state-specific scales based on the mean and SD of items that appear to be equivalent in *National* versus *State* scales.

Appendix B

How should the metric be adjusted so that a test scale is equivalent in meaning to the reference scale?

An initial scale (*test scale*) at the national level is created by fitting the data to the single-parameter Rasch model by maximum likelihood method. The metric of the scale is set equivalent to that of the global (*reference*) scale by constraining the mean and standard deviation (SD) of a subset of items (the metric adjustment subset) to be equal to the mean and SD of the equivalent items in the *reference* scale (for details, see Cafiero et al., 2018, Ballard et al., 2013, Nord 2002). More precisely, the adjustment is done by linearly transforming the severity parameters of items similarly worded in the two settings, based on the mean and SD of equivalent items in both surveys using the following transformation rule:

$$\frac{b_1 - mean_1}{SD_1} = \frac{b_2 - mean_2}{SD_2}$$

where $b1$ and $b2$ are estimated severities of the common items in two groups of populations with $mean_1$ and SD_1 and $mean_2$ and SD_1 being their respective mean and SD. Therefore,

$$b1 = \frac{SD_1}{SD_2}(b_2 - mean_2) + mean_1$$

This would give the slope (A) and intercept (B) of the linear transformation. Once the A and B parameters of the transformation are determined, they can be applied to all parameter estimates in the calibration run to be transformed.

The linear parameters of the transformation are determined using only the items which are common to the two calibration runs. To assess whether items in the metric adjustment set are appropriate for equating the metrics of the test scale and the reference scale, the severity of the items in the test scale are plotted against the severity of the items in the reference scale (see Bickel et al., 2000). Under ideal conditions the association between two sets of item scores is perfectly linear. Identical relative severities of two sets of items, equivalent in meaning, confirms that the corresponding items do, in fact, have the same meaning in two different populations (Nord et al., 2002).