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Food insecure households faced greater challenges putting healthy food on the table during the COVID-19 pandemic in Australia

Katherine Kent [a,b,*], Sandra Murray [b], Beth Penrose [c], Stuart Auckland [d], Stephanie Godrich [e], Elizabeth Lester [f], Denis Visentin [b]

[a] School of Health Sciences, Western Sydney University, New South Wales, Australia
[b] School of Health Sciences, University of Tasmania, Tasmania, Australia
[c] Tasmanian Institute of Agriculture, University of Tasmania, Tasmania, Australia
[d] Centre for Rural Health, University of Tasmania, Tasmania, Australia
[e] School of Medical and Health Sciences, Edith Cowan University, Western Australia, 6230, Australia
[f] Institute for Social Change, University of Tasmania, Tasmania, Australia

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ABSTRACT

The COVID-19 pandemic negatively affected the Australian food supply. However, it has remained unclear how food access, food availability and consumption were impacted, especially for households experiencing food insecurity. This study aimed to determine the association between food security and cooking and eating habits, food access and availability, self-sufficiency and perceptions of the food supply at the beginning of the COVID-19 pandemic in Tasmania, Australia. Throughout May–June 2020 during strict social distancing restrictions, a cross-sectional survey was conducted including the U.S. Household Food Security Survey Module Six-Item Short Form, twenty Likert scale questions on cooking and eating habits, food access, self-sufficiency and perceptions of the food supply (responses from 1 = strongly agree to 5 = strongly disagree), two questions on food availability and eleven socio-demographic questions. Survey data (n = 1067) were analysed using multivariate linear regression, and binary logistic regression. Food insecure households were significantly more likely to agree they were consuming less fresh food compared with food secure households (Mean difference between scale responses (MD) = 0.66; 95%CI:0.36–0.66; $p < 0.001$), and significantly more food insecure households agreed it was more difficult to get to the shops (MD = 0.49; 95%CI:0.34–0.64; $p < 0.001$) and they had less money available for food than prior to the COVID-19 pandemic (MD = 0.95; 95%CI:0.79–1.10; $p < 0.001$). Compared to food secure households, food insecure households were at significantly greater risk of foods being unavailable to them (OR:1.75; 95%CI:1.33–2.35; $p < 0.001$) and were less likely to have sufficient food stored in their homes (OR:0.48; 95%CI: 0.33–0.687; $p < 0.001$). This study indicates there was a disproportionate impact of the COVID-19 pandemic on food insecure households, related to food availability and access, with effects on cooking and eating habits.

1. Introduction

The COVID-19 pandemic, caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) infection, was first confirmed in Australia in late January 2020 (Australian Government Department of Health, 2020). In Tasmania, Australia, an island state sitting south-east of the Australian mainland, the Director of Public Health declared a state-wide public health emergency on March 17, 2020, and strong social and physical distancing restrictions were enforced (Tasmanian Government Depa, 2020). Similar to countries around the world, the COVID-19 pandemic affected Australians in unpredictable ways. The widespread restrictions affected workforces, transportation and consequently, food supply chains (Blay-Palmer et al., 2020). There was wide-spread panic buying of foods, which forced supermarkets to restrict the sale of food items, particularly staples such as pasta and canned goods (Fedunik-Hofman, 2020). Additionally, there were restrictions on movements of people, goods, and services, coupled with economic impacts on households and businesses (O'Sullivan et al.,

* Corresponding author. Locked Bag 1797, Penrith, NSW, 2751, Australia.
E-mail addresses: k.kent@westernsydney.edu.au (K. Kent), Sandra.murray@utas.edu.au (S. Murray), beth.penrose@utas.edu.au (B. Penrose), stuart.auckland@utas.edu.au (S. Auckland), s.godrich@ecu.edu.au (S. Godrich), elizabeth.lester@utas.edu.au (E. Lester), denis.visentin@utas.edu.au (D. Visentin).

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2020). The culmination of these circumstances may have contributed to issues associated with the availability of food and access to food, and changed cooking and eating habits.

Food security is when all people at all times have access to enough safe, healthy food to meet their needs (The Food and Agriculture Organization (FAO), 2002). Food security comprises four inter-related dimensions: sufficient production or availability of food, sufficient access to food, adequate food utilization, and stability of these factors over time, with an absence of any of these conditions indicating food insecurity (Clay, 2002). The multifaceted definition of food insecurity illustrates the complexity of the relationship between food insecurity and an individual's environment and social standing (Calloway et al., 2019). We have previously reported the prevalence and sociodemographic predictors of food insecurity during the COVID-19 pandemic in Australia (Kent et al., 2020a), reporting a food insecurity prevalence of 26% which is more than five times higher than Australian pre-COVID-19 estimates of 4–5%, determined using a single-item screening tool (Australian Bureau of Statistics (ABS), 2015; Temple, 2008). Among these households, 14% experienced more severe food insecurity, indicating they regularly skipped meals or went without food (Kent et al., 2020a). The strongest predictor of food insecurity in our analysis was loss of at least 25% or more of usual income because of the pandemic (Kent et al., 2020a).

Food insecurity can result from many environmental and social barriers that make healthful food choices difficult (Calloway et al., 2019), and consequently food insecurity is related to inadequate diet quality (Kendall et al., 1996) including lower dietary diversity (Rukundo et al., 2016) and poorer health outcomes (Ramsey et al., 2012). In particular, food insecure households can face many challenges related to access and availability of healthy food, which food secure households may not have to confront (Kaiser et al., 2019). For example, people living within food insecure households often have transportation concerns and live a greater distance from food shops which stock sufficient healthy food options (Freedman, 2009). Additionally, food shopping patterns in food insecure households differ from food secure households, were they are able to shop less frequently affecting their ability to purchase perishable items such as fresh fruits and vegetables (Ma et al., 2017). Therefore, in addition to determining who experienced food insecurity in Australia during the beginning of the COVID-19 pandemic, further understanding of the challenges related to food access, availability and changes in cooking and eating habits and their relationship with food insecurity is important to identify critical areas for intervention that support vulnerable households. Therefore, this study aimed to determine the association between food security, cooking and eating habits, food access and availability, self-sufficiency and perceptions of the food supply during the beginning of the COVID-19 pandemic in Australia when strong social and physical distancing restrictions were in place. It was hypothesised that in comparison to food secure respondents, food insecure respondents will be more likely to agree that.

- their cooking and eating habits have been changed
- they have experienced lowered food access and availability
- they have lower levels of self-sufficiency,
- the food supply was impacted during the pandemic.

In addition, it was hypothesised that in comparison to food secure respondents, food insecure respondents would be more likely to report food was unavailable to them and less likely to have sufficient food stored in their homes.

2. Methods

2.1. Study population and data collection

Approximately a fortnight after the COVID-19 pandemic was declared a public health emergency in Tasmania on March 17, 2020, stay at home orders were imposed for a period of four weeks, and in some regions further lockdowns were imposed for several weeks longer due to small outbreaks of the virus (Jarvie, 2020). Tasmania imposed strict travel restrictions, and interstate travelers were not allowed to enter the state without a mandatory 2 week quarantine (Jarvie, 2020). As a consequence of strict public health orders, Tasmania has had no cases of community transmission of COVID-19 since May 2020 (to the point of writing in early October 2021) and public health restrictions began to be scaled back on June 9, 2020, but border restrictions remained. To capture experiences during a period of strict public health orders, a cross-sectional survey was conducted through "The Tasmania Project" between 25th May and June 7, 2020 in Tasmania, Australia with a non-random sample of adult residents aged 18 years and over. Participants were recruited using convenience sampling methods by promoting the online survey through social media. In addition, the link was disseminated through Tasmanian community groups and research mailing lists, and recipients were encouraged to share the link to facilitate snowball sampling. The survey was also promoted using media interviews. This primary aim of the survey was to determine the prevalence of food insecurity during the COVID-19 pandemic, which has been previously reported (Kent et al., 2020a).

Potential participants were provided with a participant information sheet and were screened for inclusion to ensure they were aged 18 years and over and currently residing in Tasmania, Australia. Participants confirmed they had read and understood the participant information sheet before being allowed to proceed to the online, self-administered survey, hosted on the SurveyMonkey platform (SurveyMonkey Inc., San Mateo, California, USA).

As the COVID-19 pandemic and associated social distancing restrictions were rapidly changing and the study aimed to measure experiences during a period of lockdown, the survey start and finish date determined the final sample size. Due to the wide variety of convenience sampling and snowball recruitment methods used, the number of people who received a survey invitation is unknown. However, 1432 potential participants clicked on the survey link and attempted the screening questions (Tasmanian resident status and aged 18 years and over). Of these, 22 people did not meet this criteria and were exited from the survey. A further 168 potential participants exited the survey after reading the participant information sheet and a further 8 clicked the option that they did not consent to participate, and were exited from the survey, and 1234 potential participants entered the survey. Of these, 64 participants did not answer a single question, and therefore they were excluded, to leave a final sample of 1170.

The study was conducted in accordance with the Declaration of Helsinki, and the protocol was approved by the University of Tasmania's Social Sciences Human Research Ethics Committee (Ethics Project ID: 20587).

2.2. Survey outcomes

Food security status was determined using the U.S. Household Food Security Survey Module (HFSSM): Six-Item Short Form using a reference period of the previous 30 days (United States Department of Agriculture (USDA), 2014). The HFSSM-six item short form is a screening tool that has been validated against the longer 18-item food security questionnaire from the United States Department of Agriculture (Rose et al., 1997). The HFSSM-six item short form comprises six questions to determine whether limited financial resources have led to inadequate food access, availability and utilization at a household level. Responses to the six questions were coded in accordance with the user notes (Bickel et al., 2000), where each affirmative response was assigned a score of 1. Summed raw scores were used to categorize respondents as having high (0), marginal (Australian Government Department of Health, 2020), low (Blay-Palmer et al., 2020; Fedunik-Hofman, 2020; Tasmanian Government Depa, 2020) or very low food security (O'Sullivan et al., 2020; The Food and Agriculture Organization (FAO), 2002). For analyses, the high

security group was treated as food secure, and the marginal, low and very low food security groups were combined into one category (food insecure), in line with the advice of some researchers who have recommended classifying a single instance of food insecurity as food insecure (Tarasuk et al., 2018). It should be noted that while a single instance of food insecurity was deemed the appropriate cut off in this study, there are inconsistencies in the literature for which cut off value should be applied to deem an individual as "food insecure". In some research a cut off of 2 or even 3 instances of food insecurity are used. The cut off of 1 in this study was determined as 44% of people who responded affirmatively to the first question "The food that (I/we) bought just didn't last, and (I/we) didn't have money to get more" (Kent et al., 2020a) did not indicate an affirmative response to any other item on the HFSSM six item short form. If our study applied only a single item screening tool, which is the most commonly used tool in Australia and used for estimating pre-COVID-19 prevalence statistics in Tasmania, these respondents would have been classified as food insecure (McKay et al., 2019). Therefore the authors argue that is the most appropriate way to determine food security status in this setting.

Twenty statements relating to how the COVID-19 pandemic impacted respondents' cooking and eating habits, food access, self-sufficiency and perceptions of the food supply were developed. These were based on the main concepts underpinning food security (availability, access, utilization and stability) (Gross et al., 2000) and in response to anecdotal challenges to food availability, access and supply related to the COVID-19 pandemic and associated social and physical distancing restrictions. The developed survey questions were evaluated for face validity by an group of University of Tasmania academic and professional staff members collaborating on The Tasmania project, which was used to refine the language of the questions. Five of these questions related to cooking and eating habits, six related to food access, three related to self-sufficiency, and five related to perceptions of the food supply. Responses to these statements followed a 5-point Likert scale (strongly agree, agree, neither agree nor disagree, disagree and strongly disagree). Food availability was also determined using two questions, where respondents also asked to indicate whether over the previous 30 days they had wanted to buy a food item that was not available in the shops for the following food groups: fruit, vegetables, meat, dairy, grain-based foods, and discretionary foods. Participants could select all that applied to them. Additionally, respondents were asked to indicate how many days of food they had stored in their homes from three response options: 1–7 days, 4–14 days or more than 14 days.

Eleven socio-demographic variables were collected; age, gender, whether participants identified as Aboriginal and/or Torres Strait Islander, whether they were living with a disability, local government area of residence, highest level of education, employment status, residency status, and household composition. Financial questions included household income, whether they had lost any income as a result of the COVID-19 pandemic and whether they were receiving any government COVID-19 related support payments.

2.3. Data analysis

Data sets were exported from SurveyMonkey to IBM SPSS Statistics for Windows, version 26.0 (IBM Corp. Armonk, NY, USA) and prepared for statistical analysis. Data were cleaned by checking for completeness and outliers. Participants who did not complete the HFSSM six item short form (n = 106) were excluded from the analyses and participants who missing values for a sociodemographic and/or scale variable were excluded from multivariate analysis which included that variable. The significance level for all analyses was set at $p < 0.05$.

A binary variable of food security status was generated for the univariate logistic regression analyses, where food secure was determined by a score of 0, and food insecure was a score of 1–6 on the HFSSM six item short form. The scale questions were assigned a numeric value, with 1 = strongly agree, 2 = agree, 3 = neither agree nor disagree, 4 = disagree and 5 = strongly disagree. A new variable was created by combining the affirmative and negative responses to provide three categories (1 = strongly agree or agree, 2 = neither agree nor disagree, 3 = disagree or strongly disagree), to allow for easy an comparison of the proportion of food secure and food insecure respondents who either agreed or disagreed with these statements. In addition, several of the socio-demographic variables were recoded into a smaller number of categories for ease of interpretation. Recoded variables included collapsing thirty local government areas of residence categories to either rural or urban dwelling regions. Age categories were developed from the continuous variable (18–25 years, 26–35 years, 36–45 years, 46–55 years, 56–65 years, 65+ years). Disability status was recoded from three options (no, yes a little, yes a lot) to two (yes, no) by collapsing the affirmative responses. Household composition was reduced from ten options to five (couple with no dependents, couple with dependents, single adult with dependents, single person house, other [group/share]). Highest education status achieved was recoded from eight options into three (university degree, diploma/TAFE qualification, high school qualification). Employment status was recoded from eight options to three (employed [including self-employed]), unemployed and other [which included student, volunteer, retired and other]). Missing values ranged from 0.3% to 0.6% across the scale variables, and 6.2%–8.8% across the sociodemographic variables.

All variables were assessed for normality using the Shapiro-Wilk test and were determined to be normally distributed. Cross-tabulations with chi-square statistic were employed to generate descriptive statistics related to food security status (food secure vs food insecure) with the socio-demographic variables. Descriptive statistics (n (%) respondents in each category and mean ± standard deviation (SD) for agreement scores) were developed for the statements of food access and food-related behaviors during the COVID-19 pandemic. A composite score for cooking and eating habits, food access, self-sufficiency and perceptions of the food supply was generated by calculating the average of scale questions within each category. Cronbach's alpha was conducted on the scale items to assess internal consistency with the minimum acceptable value for Cronbach's alpha of 0.70 (Tavakol & Dennick, 2011). Univariate and multivariate linear regression was performed to determine the relationship between food security status and statements of cooking and eating habits, food access, self-sufficiency, and perceptions of the food supply. The combination of univariate and multivariate analyses, assists our interpretation of the contribution of key demographic characteristics towards influencing the survey outcomes. The multivariate analyses included relevant sociodemographic characteristics associated with food security status (Kent et al., 2020a): age, gender, rurality, Aboriginal and/or Torres Strait Islander status, disability status, education level, household income, residency status, and household composition. Binary logistic multivariate regression was performed (adjusting for age, gender, rurality, Aboriginal and/or Torres Strait Islander status, disability status, education level, household income, residency status, and household composition) to report odds ratios for food insecurity ('food secure' was the reference category) related to the availability of food groups over the previous 30 days, and number of days of food stored in their homes, to compare the independent relationship between food security status and these two outcomes.

3. Results

3.1. Participant and household survey characteristics

In total, there were n = 1170 survey respondents, and n = 1067 completed the HFSSM six item short form and were assigned a food security status. Of these survey respondents, most were female (77%) and aged over 56 years of age (46%), with no significant difference in proportions of food secure and food insecure respondents between age categories or gender according to a Chi-square test (Table 1). A significantly greater proportion of respondents who reported identifying as

Table 1
Proportion (n (%)) of key socio-demographic characteristics of the study sample according to food security status.

Demographic characteristics	Category	Total n (%)	Food Secure n (%)	Food Insecure n (%)	χ2	p-value
Age Category	18–25	28 (2.6)	16 (57.1)	12 (42.9)	9.6	0.087
	26–35	117 (11.0)	80 (68.4)	37 (31.6)		
	36–45	201 (18.8)	146 (72.6)	55 (27.4)		
	46–55	234 (21.9)	174 (74.4)	60 (25.6)		
	56–65	284 (26.6)	221 (77.8)	63 (22.2)		
	65+	203 (19.0)	157 (77.3)	46 (22.7)		
Gender	Female	840 (76.7)	626 (74.5)	214 (25.5)	0.3	0.882
	Male	249 (22.7)	185 (74.3)	64 (25.7)		
	Other	6 (0.6)	5 (83.3)	1 (16.7)		
Aboriginal and/or Torres Strait Islander	Yes	25 (2.3)	11 (44.0)	14 (56.0)	12.6	<0.001
	No	1093 (97.7)	804 (73.6)	264 (24.7)		
Disability	Yes	238 (21.8)	146 (61.3)	92 (38.7)	28.1	<0.001
	No	856 (78.2)	670 (78.3)	186 (21.7)		
Rurality	Urban	792 (72.2)	612 (77.3)	180 (16.4)	10.9	0.001
	Rural	305 (27.8)	206 (67.5)	99 (32.5)		
Education	University	737 (67.4)	591 (80.2)	146 (19.8)	28.2	<0.001
	Diploma/TAFE	210 (19.2)	135 (64.3)	75 (35.7)		
	High School	147 (13.4)	90 (61.2)	57 (38.8)		
Employment	Employed	679 (62.0)	521 (76.7)	158 (23.3)	17.1	<0.001
	Unemployed	56 (5.1)	29 (51.8)	27 (48.2)		
	Other	360 (32.9)	267 (74.2)	93 (25.8)		
Residency	Born in Australia	869 (79.3)	645 (74.2)	224 (25.8)	14.1	0.003
	Born overseas, citizen	179 (16.3)	144 (80.5)	35 (19.6)		
	Permanent resident	31 (2.8)	21 (67.7)	10 (32.3)		
	Temporary resident	17 (1.6)	7 (41.2)	10 (58.8)		
Household status	Couple no dependents	471 (43.1)	372 (79.0)	99 (21.0)	20.1	<0.001
	Couple, dependents	307 (28.1)	226 (73.6)	81 (26.4)		
	Single parent	65 (6.0)	35 (53.9)	30 (46.2)		
	Living alone	199 (18.2)	145 (72.9)	57 (27.1)		
	Other (group/share)	51 (4.7)	37 (72.6)	14 (27.5)		
Household income (in AUD)	<$20,000	76 (7.0)	38 (50.0)	38 (50.0)	66.5	<0.001
	$20,000- $40,000	153 (14.0)	93 (60.8)	60 (30.9)		
	$40,000- $60,000	122 (11.2)	88 (72.1)	34 (27.9)		
	$60,000- $80,000	127 (11.7)	95 (74.8)	32 (25.2)		
	$80,000- $100,000	137 (12.6)	109 (80.0)	28 (20.4)		
	$100,000- $160,000	182 (16.7)	151 (83.0)	31 (17.0)		
	>$150,000	152 (13.9)	136 (89.5)	16 (10.5)		
COVID-related Income loss	No loss	720 (65.8)	568 (78.9)	152 (21.1)	46.7	<0.001
	>25%	172 (15.7)	129 (75.0)	43 (25.0)		
	25–49%	79 (7.2)	46 (58.2)	33 (41.8)		
	50–74%	36 (3.3)	19 (52.8)	17 (47.2)		
	75–99%	17 (1.6)	6 (35.3)	11 (64.7)		
	100%	18 (1.7)	9 (50.0)	9 (50.0)		
Government support payments	No, employed	893 (83.9)	682 (76.4)	211 (23.6)	21.2	<0.001
	Yes, JobKeeper	96 (9.0)	70 (72.9)	26 (27.1)		
	Yes, JobSeeker	52 (4.9)	25 (48.1)	27 (51.9)		
	Unemployed no support payments	23 (2.2)	16 (69.6)	7 (30.4)		
All participants		N = 1067	794 (74.4)	273 (25.6)		

Between group comparison derived from Chi-square test.

Aboriginal and/or Torres Strait Islander, as living with a disability and living in a rural area were food insecure (Table 1). Food insecurity was also significantly higher among respondents with lower than a university degree and those who were unemployed (Table 1). Food insecurity was also higher in single parent households, and in households in lower income brackets. A higher proportion of respondents who reported losing income because of the COVID-19 pandemic were food insecure, in addition to respondents receiving the government support JobSeeker payment (Table 1). The Cronbach's alpha score for the survey was 0.820.

3.2. Cooking and eating habits

Accounting for sociodemographic factors, food insecure respondents were significantly more likely to agree that they were consuming less fresh food as a result of the COVID-19 pandemic (Table 3), where 54% of food insecure respondents agreed they were buying different types of foods compared to 43% of food secure respondents (Table 2). Similar proportions of both food secure and food insecure respondents neither agreed nor disagreed that they had increased the amount of food they had bought during the pandemic (Table 2). However, food insecure respondents were significantly more likely to agree that they were preparing/cooking food differently and storing food differently (Table 3). The composite score for cooking and eating habits indicates that overall, food insecure respondents cooking and eating habits were significantly more impacted than food secure respondents.

3.3. Food access

A higher proportion of food insecure respondents (28%) agreed that

Table 2
Proportion (n (%)) of respondents agreement with statements of food access and supply according to food security status.

		Food secure n (%)	Food insecure n (%)
Cooking and eating habits			
I am consuming less fresh food	Strongly Agree and Agree	95 (11.0)	86 (28.3)
	Neither Agree nor Disagree	61 (7.1)	36 (11.8)
	Disagree and Strongly Disagree	705 (81.9)	182 (59.9)
I have increased the amount of food I have bought	Strongly Agree and Agree	296 (34.3)	110 (36.2)
	Neither Agree nor Disagree	119 (13.8)	48 (15.8)
	Disagree and Strongly Disagree	447 (51.9)	146 (48.0)
I have bought different types of food	Strongly Agree and Agree	370 (43.0)	164 (53.8)
	Neither Agree nor Disagree	119 (13.8)	55 (18.0)
	Disagree and Strongly Disagree	371 (43.1)	86 (28.2)
I am preparing/cooking food differently	Strongly Agree and Agree	307 (35.7)	155 (50.8)
	Neither Agree nor Disagree	99 (11.5)	57 (18.7)
	Disagree and Strongly Disagree	454 (52.8)	93 (30.5)
I am storing food differently	Strongly Agree and Agree	238 (27.6)	140 (46.1)
	Neither Agree nor Disagree	112 (13.0)	57 (18.8)
	Disagree and Strongly Disagree	511 (59.3)	107 (35.2)
Food access			
I am buying food from different shops	Strongly Agree and Agree	401 (46.7)	170 (55.7)
	Neither Agree nor Disagree	69 (8.0)	33 (10.8)
	Disagree and Strongly Disagree	388 (45.2)	102 (33.4)
I am buying more food online	Strongly Agree and Agree	205 (23.9)	70 (23.0)
	Neither Agree nor Disagree	60 (7.0)	27 (8.9)
	Disagree and Strongly Disagree	592 (69.1)	207 (68.1)
I am buying more food imported from overseas	Strongly Agree and Agree	370 (43.0)	164 (53.8)
	Neither Agree nor Disagree	119 (13.8)	55 (18.0)
	Disagree and Strongly Disagree	371 (43.1)	86 (28.2)
it is more difficult to get to shops (i.e. transport)	Strongly Agree and Agree	84 (9.8)	73 (23.9)
	Neither Agree nor Disagree	110 (12.8)	54 (17.7)
	Disagree and Strongly Disagree	667 (77.5)	178 (58.4)
I am buying food more often	Strongly Agree and Agree	185 (21.5)	100 (33.0)
	Neither Agree nor Disagree	78 (9.1)	34 (11.2)
	Disagree and Strongly Disagree	597 (69.4)	169 (55.8)
I have less money available to buy food	Strongly Agree and Agree	95 (11.0)	86 (28.3)
	Neither Agree nor Disagree	61 (7.1)	36 (11.8)
	Disagree and Strongly Disagree	705 (81.9)	182 (59.9)
Self sufficiency			
I am growing more of my own food	Strongly Agree and Agree	282 (32.8)	121 (39.8)
	Neither Agree nor Disagree	173 (20.1)	57 (18.8)
	Disagree and Strongly Disagree	404 (47.0)	126 (41.4)
I have caught less of my own food	Strongly Agree and Agree	112 (13.0)	66 (21.8)
	Neither Agree nor Disagree	440 (51.2)	148 (48.8)
	Disagree and Strongly Disagree	308 (35.8)	89 (29.4)
I have become more interested in how to grow or catch/hunt food	Strongly Agree and Agree	251 (29.2)	123 (40.3)
	Neither Agree nor Disagree	193 (22.4)	69 (22.6)
	Disagree and Strongly Disagree	416 (48.4)	113 (37.0)
Perceptions of the food supply			
there is less variety in the food available to me	Strongly Agree and Agree	282 (32.7)	152 (50.3)
	Neither Agree nor Disagree	98 (11.4)	43 (14.2)
	Disagree and Strongly Disagree	483 (56.0)	107 (35.4)
food is more expensive	Strongly Agree and Agree	344 (40.1)	197 (64.8)
	Neither Agree nor Disagree	232 (27.1)	72 (23.7)
	Disagree and Strongly Disagree	281 (32.8)	35 (11.5)
the food available is poorer quality	Strongly Agree and Agree	91 (10.6)	82 (27.1)
	Neither Agree nor Disagree	218 (25.4)	106 (35.0)
	Disagree and Strongly Disagree	550 (64.0)	115 (38.0)
some foods are not as safe	Strongly Agree and Agree	52 (6.0)	50 (16.6)
	Neither Agree nor Disagree	137 (15.9)	96 (31.8)
	Disagree and Strongly Disagree	673 (78.1)	156 (51.7)
more food is wasted in my household	Strongly Agree and Agree	26 (3.0)	25 (8.2)
		47 (5.5)	30 (9.8)

(*continued on next page*)

Table 2 (*continued*)

		Food secure n (%)	Food insecure n (%)
	Neither Agree nor Disagree Disagree and Strongly Disagree	789 (91.5)	250 (82.0)
I have NOT changed the food I buy and consume	Strongly Agree and Agree	474 (55.0)	121 (39.8)
	Neither Agree nor Disagree	93 (10.8)	38 (12.5)
	Disagree and Strongly Disagree	295 (34.2)	145 (47.7)

they have had less money available for food in comparison to food secure respondents (11%) (Table 2), which was significantly different between groups after adjusting for important sociodemographic characteristics including household income (Table 3). Food insecure respondents were also significantly more likely to report buying food more often and buying food from different shops (Table 3). There was no difference between food secure and food insecure respondents' level of agreement with the statement about buying more food online and increasing the amount of food they bought, with most respondents in both groups responding negatively to these statements (Table 2). The composite score for food access indicates that overall, food insecure respondents were significantly more likely to agree that their access to food had been impacted by the COVID-19 pandemic in comparison to food secure respondents.

3.4. Self sufficiency

Approximately a third of all respondents (40% of food insecure and 33% of food secure respondents) agreed that they were growing more food as a result of the COVID-19 pandemic, with no significant difference between groups in the multivariate analysis (Table 2). However, food insecure respondents were significantly more likely to agree that they have caught less of their own food (e.g. fish) because of social distancing restrictions (Table 3). Interestingly, 40% of food insecure and 30% of food secure respondents agreed that they are now more interested in learning how to grow or catch/hunt food because of the COVID-19 pandemic (Table 2).

3.5. Perceptions of the food supply

Accounting for sociodemographic factors, food insecure respondents were significantly more likely to agree that there was less variety in the food available to them and that food was more expensive during the pandemic (Table 3). Most food insecure respondents (65%) reported that food was more expensive since the beginning of the COVID-19 pandemic in comparison to 40% of food secure respondents (Table 2). Food insecure respondents were also significantly more likely to agree that the food available was of poorer quality and was not as safe (Table 3), however only a minority of respondents overall agreed with these statements overall (Table 2). Most respondents (92% of food secure and 82% of food insecure respondents) disagreed with the statement that more food was wasted in their household during the pandemic (Table 2).

3.6. No change

Respondents who agreed that they had not changed the food they buy and consume were significantly more likely to be categorised as food secure (Table 3). Approximately half of food insecure respondents (48%) disagreed with this statement in comparison to 34% of food secure respondents (Table 2).

3.7. Food availability and household storage

Adjusting for sociodemographic factors, food insecure respondents were significantly more likely to report wanting to buy food items unavailable to them than for food secure respondents (70% vs 57%; OR:1.79; 95% CI: 1.28–2.52; $p = 0.001$) (Fig. 1). Moreover, a greater proportion of food insecure respondents reported being unable to buy items from all food groups in comparison to food secure respondents (Fig. 1), with food insecure respondents significantly more likely to report being unable to access fruits (OR:1.99; 95% CI: 1.31, 3.03; $p = 0.001$), vegetables (OR:2.04; 95% CI: 1.41, 2.86; $p < 0.001$), meat (OR:1.85; 95% CI: 1.29, 2.63; $p = 0.001$) dairy (OR:1.83; 95% CI: 1.14, 2.93; $p = 0.013$) and grain foods (OR:1.53; 95% CI: 1.11, 2.10; $p = 0.009$). Comparatively, only a small proportion of respondents reported being unable to purchase discretionary foods, however there was no significant difference between food secure and food insecure respondents being unable to access them (OR:3.06; 95% CI: 0.91, 10.27; $p = 0.070$).

The majority of food insecure respondents (51%) had less than a week of food stored, compared to 39% of food secure respondents who had 7–14 days' worth stored. Adjusting for sociodemographic factors, food insecure respondents were significantly more likely than food secure respondents to have a week or less of food stored (OR:1.85; 95% CI: 1.36–2.49; $p < 0.001$ (Fig. 2). A similar proportion of food secure and food insecure respondents had between seven to ten days of food stored (OR:0.89; 95% CI: 0.66–1.22; $p = 0.489$). Food insecure respondents were significantly less likely to report having more than 14 days of food stored (OR:0.46; 95% CI: 0.31–0.687; $p < 0.001$) when compared with food secure respondents.

4. Discussion

This cross-sectional study assessed cooking and eating habits, food access and availability, self-sufficiency, perceptions of the food supply, and the relationship with food security during the beginning of the COVID-19 pandemic in Australia. Our results demonstrate that between late April (30 days prior to the start of the survey) and early June 2020 there was a disproportionate impact on food insecure households in our sample in relation to the availability of food, their ability to access food and an impact on their cooking and eating habits resulting from the social and physical distancing restrictions of the COVID-19 pandemic. The prevalence of food insecurity in our sample was 26% (Kent et al., 2020a), which is higher than pre-pandemic estimates of 6% in Tasmania, Australia (Tasmanian Department of Health, 2020)[26, page 12], and was higher in rural dwelling respondents and people living with a disability. Comparison of this statistic with the 6% 2019 estimate is difficult given the use of a single-item screening tool in the 2019 survey, however, 22% of respondents to our survey indicated agreement the equivalent question in the HFSSM six item short form (Kent et al., 2020a) indicating that it is likely there was a substantial increase in food security. The prevalence of food insecurity also increased in other countries during the COVID-19 pandemic, with studies in the USA and UK reporting prevalence statistics from 16% up to 64% in vulnerable groups (Loopstra, 2020; Niles et al., 2020; Owens et al., 2020; Wolfson & Leung, 2020), most commonly using the HFSSM six item short form. As there are some inconsistencies in the literature regarding how many instances of food insecurity are used to indicate food insecurity, and some manuscripts do not clearly indicate the cut off applied, care must be taken when comparing results across studies.

In our study, food insecure respondents were more likely to agree that they were consuming less fresh food and they were buying different types of foods during the pandemic. This finding is similar to research in a USA sample in which individuals experiencing food insecurity were

Table 3
Logistic regressions results showing crude and adjusted mean difference estimates of associations between food security status and the agreement with statements about the impact of the COVID-19 pandemic on cooking and eating habits, food access, self-sufficiency and perceptions of the food supply, (a score >3 would indicate general agreement and <3 would indicate general disagreement).

	n	Total	Food Secure	Food Insecure	Univariate Regression				Multivariate Regression			
		Mean score between 1 = Strongly Agree to 5 = Strongly Disagree (SD)		Mean (SD)	MD	t	95% CI	p	MD	t	95% CI	p
Cooking and eating habits												
I am consuming less fresh food	1167	3.9 (1.1)	4.0 (1.0)	3.4 (1.2)	0.66	9.45	[0.52, 0.80]	<0.001	0.51	6.76	[0.36, 0.66]	<0.001
I have increased the amount of food I have bought	1168	3.2 (1.2)	3.2 (1.2)	3.1 (1.2)	0.14	1.82	[-0.01, 0.30]	0.069	0.11	1.23	[-0.62, 0.27]	0.220
I have bought different types of food	1167	2.9 (1.1)	3.0 (1.1)	2.7 (1.0)	0.35	4.73	[0.20, 0.49]	<0.001	0.34	4.20	[0.18, 0.49]	<0.001
I am preparing/cooking food differently	1167	3.1 (1.2)	3.3 (1.0)	2.7 (1.0)	0.54	6.77	[0.38, 0.69]	<0.001	0.49	5.56	[0.32, 0.66]	<0.001
I am storing food differently	1167	3.3 (1.2)	3.4 (1.1)	2.8 (1.1)	0.59	7.89	[0.45, 0.74]	<0.001	0.54	6.49	[0.38, 0.71]	<0.001
Composite Score	1157	3.3 (0.8)	3.4 (0.7)	2.9 (0.7)	0.45	8.95	[0.35, 0.55]	<0.001	0.39	7.26	[0.28, 0.49]	<0.001
Food access												
I am buying food from different shops	1165	2.9 (1.2)	3.0 (1.2)	2.7 (1.2)	0.33	4.07	[0.17, 0.49]	<0.001	0.31	3.44	[0.13, 0.48]	0.001
I am buying more food online	1163	3.7 (1.3)	3.7 (1.3)	3.7 (1.3)	0.08	0.86	[-0.09-0.25]	<0.001	0.09	0.94	[-0.10, 0.23]	0.349
I am buying more food imported from overseas	1166	4.2 (0.8)	4.3 (0.8)	4.1 (0.9)	0.22	4.01	[0.11, 0.33]	<0.001	0.17	2.68	[0.04, 0.28]	0.007
it is more difficult to get to shops (i.e. transport)	1168	3.8 (1.1)	4.0 (1.0)	3.4 (1.2)	0.54	7.85	[0.40, 0.67]	<0.001	0.49	6.42	[0.34, 0.64]	<0.001
I am buying food more often	1165	3.6 (1.2)	3.7 (1.2)	3.3 (1.3)	0.42	5.18	[0.26, 0.57]	<0.001	0.37	4.12	[0.19, 0.54]	<0.001
I have less money available to buy food	1161	3.7 (1.2)	4.0 (0.9)	2.9 (1.3)	1.10	16.4	[1.00, 1.27]	<0.001	0.95	12.3	[0.79, 1.10]	<0.001
Composite Food Access Score	1141	3.7 (0.7)	3.8 (0.6)	3.3 (0.6)	0.46	10.9	[0.38, 0.54]	<0.001	0.40	8.72	[0.31, 0.48]	<0.001
Self sufficiency												
I am growing more of my own food	1165	3.2 (1.3)	3.2 (1.2)	3.1 (1.3)	0.17	2.08	[0.10, 0.34]	0.038	0.13	1.37	[-0.05, 0.31]	0.169
I have caught less of my own food (i.e. fish)	1165	3.3 (1.1)	3.4 (1.1)	3.1 (1.1)	0.30	4.07	[0.15, 0.44]	<0.001	0.26	3.14	[0.01, 0.42]	0.002
I have become more interested in how to grow or catch/hunt food	1167	3.3 (1.2)	3.3 (1.2)	3.0 (1.2)	0.29	3.62	[0.13, 0.45]	<0.001	0.21	2.36	[0.04, 0.39]	0.019
Composite Self Sufficiency Score	1158	3.2 (0.9)	3.3 (0.9)	3.0 (0.9)	0.25	4.39	[0.14, 0.37]	<0.001	0.20	3.04	[0.07, 0.33]	0.002
Perceptions of the food supply												
there is less variety in the food available to me	1167	3.3 (1.2)	3.4 (1.2)	2.8 (1.2)	0.61	7.5	[0.45, 0.77]	<0.001	0.50	5.64	[0.33, 0.67]	<0.001
food is more expensive	1163	2.7 (1.1)	2.9 (1.0)	2.2 (1.0)	0.70	10.4	[0.57, 0.83]	<0.001	0.61	8.18	[0.46, 0.75]	<0.001
the food available is poorer quality	1164	3.5 (0.9)	3.7 (0.9)	3.1 (1.0)	0.58	9.6	[0.46, 0.69]	<0.001	0.50	7.45	[0.36, 0.63]	<0.001
some foods are not as safe	1166	3.9 (1.0)	4.1 (0.9)	3.4 (1.0)	0.64	10.2	[0.51, 0.76]	<0.001	0.50	7.27	[0.37, 0.66]	<0.001
more food is wasted in my household	1169	4.2 (0.8)	4.3 (0.8)	4.0 (0.9)	0.30	5.7	[0.20, 0.41]	<0.001	0.29	4.89	[0.18, 0.41]	<0.001
Composite Food Supply Perceptions Score	1149	3.5 (0.7)	3.7 (0.6)	3.1 (0.7)	0.56	12.9	[0.48, 0.65]	<0.001	0.48	10.1	[0.39, 0.57]	<0.001
I have NOT changed the food I buy and consume	1168	2.7 (1.3)	2.6 (1.3)	3.0 (1.2)	−0.40	−4.78	[-0.56, −0.23]	<0.001	1.15	1.93	[-0.51, −0.15]	<0.001

Respondents answered on a Likert scale from 1 to 5, where: 1 = Strongly Agree, 2 = Agree, 3 = Neither Agree nor Disagree, 4 = Disagree, 5 = Strongly Disagree; Multivariate model adjusts for age, gender, rurality, Aboriginal and/or Torres Strait Islander status, disability status, education level, household income, residency status, and household composition.

more likely to change their dietary habits due to disruptions to food access (Bin Zarah et al., 2020). Additionally, a study during the COVID-19 pandemic in Denmark, Germany and Slovenia reported that people showed an overall reduction in the consumption of fresh foods, but an increase in the consumption of food with a longer shelf life (Janssen et al., 2021). Additionally, in line with research from across the world (Bracale & Vaccaro, 2020; Deschasaux-Tanguy et al., 2021), most respondents, including half of food insecure respondents in our study agreed they were preparing and cooking food differently during the pandemic, which may due to increased home cooking as hospitality businesses and some food outlets had temporarily closed. In contrast to the widespread reporting of panic buying and food hoarding (ews (2020) Scott Mor, 2020), around half of the respondents to our survey disagreed or strongly disagreed they had increased the amount of food purchased during the pandemic.

Prior to the COVID-19 pandemic, it has been reported that a quarter (26%) of food insecure households were dissatisfied with their ability to access food, and a similar proportion (27%) reported poor access to fresh

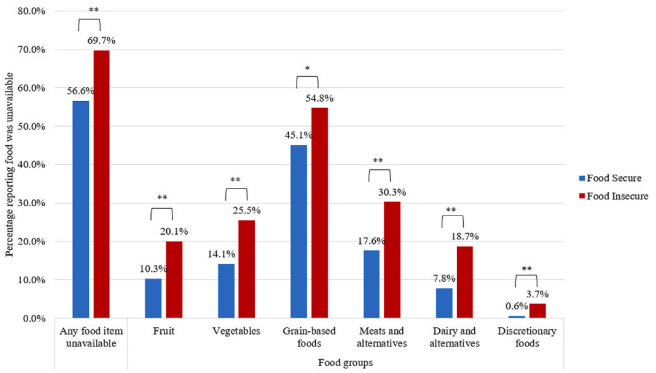

Fig. 1. Proportion of food secure and food insecure respondents who reported attempting to buy foods from each food group but it was not available (*p < 0.05, **p < 0.001 difference between groups derived from multivariate logistic regression).

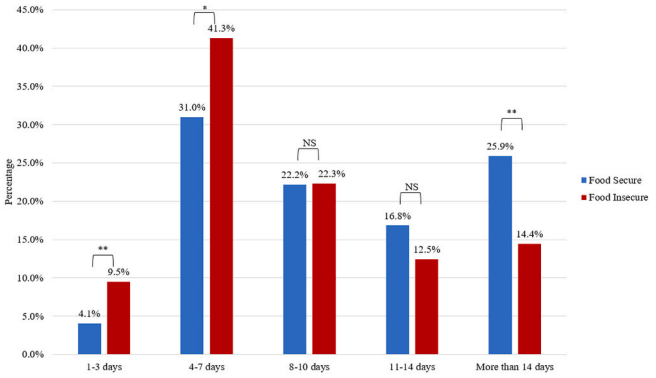

Fig. 2. Numbers of days of food stored for food secure and food insecure respondents (*p < 0.05, **p < 0.001, NS not a significant difference between groups derived from multivariate logistic regression).

fruits and vegetables (Kaiser et al., 2019). Our study demonstrates that food access for food insecure households may have been further challenged during the pandemic due to a lack of money and/or physical limitations such as lack of access to transport (Burns et al., 2010). The lack of money available for food may be a result of rising food costs, increased rates of unemployment and underemployment (Australian Bureau of Statistics (ABS), 2020), and increased household costs (Bainbridge, 2020; Killmorgen, 2020). Additionally, a quarter of food insecure respondents to our survey agreed that it was more difficult to get to shops which may be a result of reduced public transport options due to the pandemic and that Australians were discouraged from using the available public transport due to the risk of infection. In our study, food insecure respondents were also significantly more likely to report buying food more often, which may relate to the limits placed on staple food items by supermarkets, with the resulting intermittent availability of these items requiring these households to shop more frequently to ensure they could purchase enough food to meet their households needs. In international studies, the trend for online food shopping grew (Grashuis et al., 2020), but in our study most respondents (~70%) regardless of food security status did not report buying more food online, as major supermarkets had suspended delivery and 'click and collect' services during the time of the survey, except for very vulnerable households.

A greater proportion of food insecure respondents to our survey agreed that they were growing more of their own food during the COVID-19 pandemic, which may reflect concerns about the stability of the food supply, or an increased amount of time spent at home. In Australia, nurseries were insufficiently prepared to rapidly scale up to match the increase in productive home gardening and better preparation may be needed for there to be an equitable response for increased self-sufficiency in the future. Additionally, recreational boating and fishing were considered non-essential activities and were prohibited, which disproportionately impacted food insecure households' ability for self-sufficiency. Food insecure respondents were also significantly more likely to agree that they are more interested in learning how to grow or catch/hunt more food. Given the many benefits of gardening, fishing and hunting, which include access to green space and an increase in consumption of healthy foods (Soga et al., 2017), this can be seen as a positive response and further investment to support the development of knowledge and skills may contribute to maintaining higher levels of self-sufficiency in the future.

In our study, most food insecure respondents agreed there was a lower variety of food available and the cost of food increased, indicating that vulnerable households had a reduced ability to purchase a diverse diet. In Australia, increases in demand for food, coupled with food supply chain instability resulting from the COVID-19 pandemic contributed to higher import, export, producer, and consumer prices for food (United States Department of Agriculture (USDA) (2020a, 2020b); United States Department of Agriculture (USDA) (2020a, 2020b) which was most pronounced in foods such as meats (beef and pork) and eggs, dairy foods, vegetables and fruits (Trading Economics (2020), 2020). Specifically, prices of food and non-alcoholic beverages in Australia rose by 4.1 percent in the second quarter of 2020, after a 3.2 percent gain in the first quarter of 2020 (Trading Economics (2020), 2020), which is the highest inflation since 2011. Our analysis demonstrates that rising food costs appear to have impacted food insecure households disproportionately, which reflects previous research showing that food prices and limited income were key barriers to buying sufficient healthy food (Kaiser et al., 2019). Additionally, a higher proportion of food insecure respondents agreed that food was of poorer quality and some foods were not as safe during the COVID-19 pandemic. However, only a minority of respondents overall agreed with these statements, indicating the food supply continued to provide safe and high-quality produce. We have previously reported that Tasmanian consumers highly value and regularly consume regionally-grown produce (Godrich et al., 2020; Kent et al., 2020b). However, our study showed that most respondents had bought more food imported from overseas during the pandemic, highlighting an opportunity to further strengthen local food supply chains to ensure they are responsive to sudden increases in demand for fresh produce during a pandemic-situation in the future.

In our study, a lowered availability of foods impacted food insecure household disproportionately. Over half of food insecure respondents reported being unable to buy grain-based foods such as pasta and rice and many were unable to buy meats, dairy, fruits and vegetables, which are all core-foods according to the Australian Guide to Healthy Eating (National Health and Medical Research Council (NHMRC), 2013). This highlights nutritional issues for the Australian food supply during the COVID-19 pandemic, with a comparatively lower proportion of respondents reporting that discretionary (or non-core) foods were unavailable to them (4% and 0.5% of food insecure and secure respondents respectively) which respondents may have resorted to purchasing due to a lack of core foods available. Additionally, despite Australian disaster preparedness recommendations around stockpiling food for a 14-day quarantine period (New South Wales Department of Health, 2020), and to limit grocery shopping to facilitate social distancing, most food insecure respondents only reported having less than a week of food stored. This demonstrates a disconnect between public health disaster preparedness messages and the abilities and actions of households, especially food insecure households. Our findings align with previous research showing household food supplies diminished with increasing food insecurity (Dachner et al., 2010). In addition, a study in the USA during the COVID-19 pandemic identified that less than one in five (18.8%) adults with very low food security reported being able to purchase two weeks of food at a time (Wolfson & Leung, 2020). While food secure households may be able to more easily mitigate the risk of food

shortages by stockpiling food, overall household food stocks are unreliable, especially for food insecure households, highlighting a need for alternative management policies in the event of disruptions to the food supply in the future. Community-centric approaches, such as establishing community-owned food shops, have shown to be successful in reducing disparities in community food access through building a community stockpile of food and increasing the human and social capacity within a connected community (Kawashima et al., 2012).

The strengths of this study include that it may be one of the only comprehensive surveys in Australia regarding how the COVID-19 pandemic affected cooking and eating habits, food access and availability, self-sufficiency, perceptions of the food supply. This allowed a thorough investigation of many aspects of how the COVID-19 pandemic impacted food insecure households. Secondly, our study sample was substantial relative to the population of Tasmania, Australia, which had 509,965 residents at the last census (Australian Bureau of Statistics (ABS), 2016). The limitations of our study include that the survey results may not be generalisable to the entire Tasmanian population due to the convenience sampling methods employed. Further, we do not know the number of people the survey link was sent to due to the convenience and snowball recruitment methods used. Due to Tasmania being an island state off the mainland of Australia, the circumstances related to the COVID-19 pandemic these results may differ from other communities in Australia. In our study, only a single incidence of food insecurity was used to identify somebody at risk of food insecurity, whereas other comparative studies use higher cut off values of two or more instances. While efforts have been made to identify the survey tools used in each study, this limits our ability to compare statistics easily across studies. The scale questions were developed for the purpose of this survey and were not assessed for constructvalidity. Participation in this survey was limited to those who spoke fluent English, those with internet access, and those with relatively high literacy given the length of the survey, which may not be representative of all population groups, and the likelihood of participating in the survey may be associated with food insecurity, which may bias the survey results.

In conclusion, our results indicate that food insecure households appear to have experienced greater challenges accessing food and lower food availability during the beginning of the COVID-19 pandemic when compared with food secure households, which may have impacted cooking and eating habits. Learning from the outcomes of this study, policymakers have clear opportunities to improve food environments in Australia to ensure consumers have equitable access to affordable healthy food to support public health, and to buffer against the impact of future disasters and pandemics. Notably, strategies that reduce panic buying of food items (e.g. groceries) and nursery stock (e.g. seedlings for growing food) in response to emergencies would mitigate some of the challenges around the availability of food, especially for food insecure households. Additionally, long-term policies which prioritise strengthening of smaller food supply chains and local production should be encouraged, as these solutions are more resilient and responsive than current globalised supply chains in Australia (de Paulo Farias & Dos Santos Gomes, 2020). Future research should be conducted to determine the long-term impact of disruptions to availability and access to food during the COVID-19 pandemic, especially for food insecure households who may be vulnerable to poorer long-term health outcomes (Huizar et al., 2020).

Authorship

Project conceptualization, KK, SM, BP, SA, SG, DV and EL.; methodology, KK, SM, BP, SA, SG, DV and EL; software, EL.; formal analysis, DV and KK.; writing—original draft preparation, KK.; writing—review and editing, all authors. All authors have read and agreed to the final version of the manuscript.

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Ethical statement

The study was conducted in accordance with the Declaration of Helsinki, and the protocol was approved by the University of Tasmania's Social Sciences Human Research Ethics Committee (Ethics Project ID: 20587).

Declaration of competing interest

The authors declare no conflict of interest.

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