Investigating the prevalence and predictors of food insecurity: a comparison of HFSSM and EU-SILC indicators

Abstract

Purpose: Household food insecurity has been identified as a significant societal issue in both developed and developing nations, but there exists no universal indicator to approximate its prevalence. In Northern Ireland, two indicators (United States Household Food Security Survey Module (HFSSM) and the European Union Statistics on Income and Living Conditions (EU-SILC) food deprivation questions) have been used. This study examines how both indicators differ in their classification of food insecurity prevalence in a population, and also examines the relationship between various demographic and household factors, and food security status.

Methodology: Data from the Northern Ireland (NI) Health Survey 2014/15 (n=2231) were statistically analysed to examine the prevalence of food insecurity according to both indicators. Pearson's X^2 test for association and logistic regressions were used to examine associations between food security status and predictor variables.

Findings: According to the EU-SILC food deprivation questions, 8.3% (n=185) were indicated to be food insecure, while according to the HFSSM, 6.5% (n=146) were indicated to be food insecure. The HFSSM and EU-SILC regression models differed in the underlying variables they identified as significant predictors of food insecurity. Significant variables common to both modules were tenure, employment status, health status, anxiety/depression, and receipt of benefits.

Practical implications: Findings can inform policy action with regards to targeting the key contributors, and can inform policy decisions in NI and elsewhere with regards to choosing the most appropriate food insecurity indicator.

Originality/value: This study provides a contribution by identifying statistically tested predictors with applicability to other regions, and statistically comparing the HFSSM and EU-SILC indicators.

Keywords: food insecurity; food poverty; deprivation; measurement; logistic regression.

Introduction

Food insecurity, defined as *"the inability to acquire or consume an adequate quality or sufficient quantity of food in socially acceptable ways, or the uncertainty that one will be able to do so"* (Radimer *et al*., 1992, p.39), has been identified as a significant public health and social policy concern (Dowler and Lambie-Mumford, 2015; Furey, 2019), with recent survey data (Food Standards Agency – Food and You – Wave 5) finding that 10% of UK adults lived in households classified as marginally food insecure, while a further 10% lived in households with low or very low food security (Food Standards Agency, 2019).

Prior to May 2019, there was no standardised UK food insecurity measure, with variations of the United States Household Food Security Survey Module (HFSSM) and Food Insecurity Experience Scale Survey Module (FIES-SM) being used in Great Britain, while in NI, measurement has been variously via HFSSM and the European Union Statistics on Income and Living Conditions (EU-SILC) food deprivation questions. These indicators were first included in the annual NI Health Survey in 2012, and since then, use of these questions has been inconsistent, and there have been variations each year in which questions from the HFSSM are chosen. Furthermore, from 2016 onwards HFSSM questions have been removed entirely and EU-SILC questions are instead the sole measure used. EU-SILC questions are also used to assess food security in the Republic of Ireland, and the continuation of their use in NI therefore allows for all-Island comparison of food security prevalence. The HFSSM has been validated as an indicator suitable for use to approximate household food insecurity in high-income countries (Loopstra *et al*., 2019), and variations on the measure (i.e. 18-item adult and child HFSSM, 10-item adult HFSSM, 6-item short-version HFSSM, and cultural translations) have been used in various regions worldwide (Beacom *et al*., 2020). The EU-SILC is a survey developed to monitor deprivation and social exclusion across countries in the European Union (Arora *et al*., 2015) and carries four questions pertaining to food insecurity. As these four food deprivation measures were

constructed as part of a longer twenty-item survey which included questions on markers of deprivation other than food consumption, these four questions have not been validated as a separate construct to measure food insecurity (Whelan and Maitre, 2006). Furthermore, unlike the HFSSM, the EU-SILC food deprivation questions have not been validated comparably in terms of categorising respondents into varying levels or categories of food insecurity (Whelan and Maitre, 2006). Therefore it is of interest how both indicators differ in how they categorise prevalence of food insecurity and associated predictors.

Although income is commonly considered the primary predictor of food insecurity, several other predictors aside from income have been identified, such as household demographics and health status (Anderson *et al*., 2016). However, the majority of studies on the predictors of food insecurity have been carried out in North America (Beacom *et al*., 2020), and the number of similar studies in the UK is limited (Loopstra *et al*., 2019). Asserting focus on identifying and confirming anecdotal causes/predictors of food insecurity in the UK/NI can help to identify those groups experiencing food insecurity, to inform focused policy attention and targeted interventions. This is particularly timely in the current UK/NI landscape as macro-environmental factors such as changes in the welfare system, economic uncertainty related to Brexit and the COVID-19 pandemic, and the potential implications for food prices and food affordability present further concern for consumers (French and McKillop, 2017, ILO, 2020).

Recent changes to the United Kingdom (UK) social security system such as welfare reform and the introduction of Universal Credit have the potential to result in less disposable income for families who are already struggling financially, which may manifest as a driver for food insecurity. NI has been identified as one of the areas in the UK most likely to experience an increase in poverty between 2019 and 2021 as the welfare system is reformed (Hood and Waters, 2017), due to the higher proportion of people with a disability/illness which prevents them working, and a higher proportion of working age people unemployed than that of Great Britain

(Advice NI, 2013; JRF, 2014).

Moreover, continued uncertainty as to the implications of the UK's exit from the EU create further risk around the impact on food prices. A recent government report stated that the cost of border checks and tariffs businesses will incur following Brexit are likely to be passed on to the consumer resulting in increasing food prices, with food prices expected to rise between 1.4% to 5.1% depending on the food group (Parliament, 2018). One recent academic study modelled four potential post-Brexit trade scenarios, and found that under all modelled scenarios prices of fruit and vegetables (the food group under examination in the study) would increase (Seferedi *et al*., 2019). Similarly, a policy report considering the effects of Brexit on the UK food and agricultural sectors, with particular focus on the island of Ireland, further discussed the risk of increased prices and restricted supplies, particularly of fruit and vegetables. This report highlighted low-income consumers as particularly vulnerable to price increases, and predicted NI consumers to be most impacted by Brexit-related price increases (McFarlane *et al*., 2019). The aforementioned government report (Parliament, 2018) further acknowledged the risk that food inequality could increase following Brexit, as a rise in food prices is more difficult for low-income families as they spend a higher proportion of their income on food compared to those on higher incomes (DeLyon *et al*., 2017; DEFRA, 2018).

Of further concern are the implications of the COVID-19 pandemic on the financial situation of households, several of which have lost some, or all, of their primary source of income as a result of the pandemic (ILO, 2020). From the perspective of household food insecurity, this is concerning, as often food is viewed as the most flexible aspect of the household budget (Dowler, 2001), and therefore is the expense that will be reduced first, or most substantially, in order to fulfil other household budget requirements such as rental/mortgage costs and utility bills.

Although the NI Health Survey has measured food insecurity using both the HFSSM and EU-SILC indicators, to the best of the authors knowledge, these statistics and approaches have not

been compared, nor have predictors of food insecurity in NI according to either indicator been examined. This study therefore aimed to (i) examine the prevalence of food insecurity in NI according to the HFSSM and EU-SILC indicators, and (ii) examine significant predictors of food insecurity according to each indicator.

Methods

Data

Data from the NI Health Survey, a representative survey of NI households, commissioned annually by the Department of Health, was used as it carries both the HFSSM and EU-SILC questions, as well as collecting data on a range of demographic and other household factors which have been associated with food insecurity in the literature. The most recent dataset available (from the UK Data Service, as of June 2019) was the 2014/15 survey (n=4,207). The survey was interviewer-administered in participants homes, and responses were self-reported by respondents (e.g. to assess general health, participants were asked "How is your health in general, would you say it was", and respondents reported their answer on a provided 5-point Likert scale (Very Good to Very Bad). Further information about sampling procedures can be found in the survey methodology documentation (NISRA, 2019).

Defining food insecurity status

Due to dataset limitations (i.e. all HFSSM questions were not asked in the dataset), and as the EU-SILC questions are not a validated scale when used as an entity separate to the larger EU survey they are contained in, this analysis did not differentiate between the severity of the food insecurity experience. For the purposes of this research, if respondents answered at least one of the HFSSM or EU-SILC questions affirmatively they were categorised as 'food insecure'. This approach accords with the US and Canadian HFSSM scoring methodology which defines those who answer one question as being marginally food insecure, and the literature provides further precedent of defining study respondents as food insecure if they select only one response

indicating food insecurity (Kleve *et al*., 2017; Jarvela-Reijonen *et al*., 2019). Although respondents answering one or more HFSSM/EU-SILC question affirmatively will hereafter be referred to as 'food insecure' it is acknowledged that this is not a definitive, validated categorisation, but rather indicates that they are manifesting at least one food insecurity symptom, and that they are classified as at least 'marginally food insecure' according to Canadian and American classifications.

Data analysis

The purpose of this study was to examine the prevalence of food insecurity in NI, and the strength of association and significance level between identified predictors and household food insecurity status. Frequencies were used for descriptive analysis of the prevalence of food insecurity, Pearson's X^2 test was used to check associations between food insecurity and the predictor variables, and logistic regressions were used to derive the predictive models (Antwi *et al*., 2017). Both the dataset itself, as well as the survey methodology (NISRA, 2019), were examined to confirm the assumptions for both tests were satisfied prior to analysis. Pearson's X^2 test is applied to categorical data in order to assess if any observed difference between variables is statistically significant or due to chance (McHugh, 2013; Rana and Singhal, 2015), and has been used in the literature as a first-step method of checking associations between predictor variables and the dependent variable before further analysis in a logistic regression model (Chen and Zhang, 2016; Antwi *et al*., 2017). This test therefore identified the significance, or otherwise, of any observed differences between the characteristics of those who were food secure and those who were food insecure. A significance level of $p \leq 0.25$ was chosen for this test, as a more relaxed Type 1 error rate is recommended when determining variables to include in a logistic regression model in order to avoid eliminating potentially important variables (Stoltzfus, 2011; Sperandei, 2013; Antwi *et al*., 2017). Predictors which were not statistically significant were eliminated and not included in the proceeding logistic regression. Logistic regressions were then carried out to assess significant associations between food security status and these significant predictors (Ranganathan *et al*.,

2017). Prior to running the analysis, a reference variable for each categorical variable was chosen. This reference variable was either the first or last categorical response in the variable, and was usually the response of null state (e.g. 'no children', 'not in receipt of benefits'), or the response negatively associated with food insecurity in the literature (e.g. own home, good health), to assess how change in variable response affected the dependent variable. Logistic regression is used to produce an 'odds ratio' (OR) of a single explanatory variable's (predictor's) effect on the dependent variable in the presence of more than one explanatory variable (Stoltzfus, 2011; Sperandei, 2013), thus creating a framework of a household's odds of being food insecure (or otherwise) according to the predictor variables (Ngema *et al*., 2018). The confidence level for Exp (β) values (OR values) was set at 95%, therefore there is only a probability of 0.05 or less ($p \leq 0.05$) that the value for the OR lies outside of the calculated range. OR values with a significance level of ≤0.05 were therefore considered significant. This significance level has been used in comparable studies (e.g. Antwi *et al*., 2017; Hunt *et al*., 2019).

Results were considered in terms of overall model fit, as well as considering individual variable results. Various inferential tests and descriptive measures were considered when assessing model fit. The classification table shows the difference in observed and predicted model values, with better model fit being characterised by a smaller difference between observed and predicted model values (Pallant, 2016). The likelihood ratio test shows whether the model provides a significant improvement to the null model (Peng and So, 2002), i.e. whether the inclusion of explanatory variables contributes significantly to model fit. A p-value less than 0.05 shows that the Block 1 model is a significant improvement to the Block 0 (null) model. The *Nagelkerke R Square value* assesses the variation in the dependent variable and assesses the proportion of the variance explained by the regression model. It is therefore used to measure the success of predicting the dependent variable using the independent variable (Nagelkerke, 1991). A low *Nagelkerke R square value* suggests that the model may not be a good fit (Ngema *et al*., 2018). Better model fit is characterised by a p-value greater than 0.05 resulting from the *Hosmer and*

Lemeshow chi-square test. This test assumes that the model is an adequate fit for the data, therefore this null hypothesis is only rejected if $p \leq 0.05$ (Ngema *et al*., 2018).

Results

Results relating to the prevalence of food insecurity according to the EU-SILC and HFSSM measurement approaches are firstly presented, followed by findings regarding significant predictors of food insecurity according to both modules, and model fit statistics.

Prevalence of food insecurity according to the EU-SILC and HFSSM measurement approaches

Two descriptive results for both the EU-SILC and HFSSM are hereafter presented. Firstly, a breakdown of how many respondents answered each of the individual questions indicating food insecurity affirmatively. Secondly, the proportion of respondents who answered any one of the questions affirmatively/who answered none of the questions affirmatively (i.e. the proportion who are/are not classified as food insecure).

EU-SILC and HFSSM question response frequencies

Frequencies of affirmative responses to the EU-SILC questions are presented in Table 1, and to the HFSSM questions in Table 2.

INSERT TABLE 1 HERE

INSERT TABLE 2 HERE

Total categorised as food insecure according to each module

EU-SILC total score frequencies are presented in Table 3, and HFSSM total score frequencies are presented in Table 4. These tables present the total number of questions indicating food insecurity which were answered affirmatively by respondents. In total, 8.3% (n=185) of respondents were considered food insecure according to the EU-SILC, answering one or more questions affirmatively. A lower proportion of respondents, (6.5%, n=146) were considered food insecure according to the HFSSM, answering one or more questions affirmatively.

INSERT TABLE 3 HERE

INSERT TABLE 4 HERE

Predictors of food insecurity according to the EU-SILC and HFSSM measurement approaches

Pearson's chi square test of association examined significant associations between food insecurity and the predictor variables prior to variables being entered into the logistic regression model. An overview of the verification process is provided in Figure 1.

INSERT FIGURE 1 HERE

Overall, three variables (gender, number of children and carer responsibility) were not significantly associated ($p \leq 0.25$), with food security status using either the EU-SILC or HFSSM measurement classifications. These three variables were therefore eliminated from further data analysis, leaving eleven variables remaining to progress to regression analysis.

Separate logistic regression analyses were conducted with eleven predictor variables (Figure 1) as the independent variables, and the EU-SILC and HFSSM binary variables as the dependent variable. Model fit statistics for both EU-SILC and HFFSM models are presented. For each variable within EU-SILC and HFSSM models, odds ratio (OR) values are presented, along with

confidence intervals (CI), and significance levels (p-values). Categories within variables are referred to as 'variable levels' (e.g. '25-34' is a variable level of the 'age' variable).

EU-SILC model

The EU-SILC model containing all predictors was a significant improvement to the null model (χ^2 = 164.23 (27), p<0.001), indicating that the model was able to distinguish between those who were food insecure and those who were not food insecure. The model explained 16.3% (*Nagelkerke R squared*) of the variation in the dependent variable (food security status), and the overall prediction value of the model was high, as it correctly classified 91.7% of cases. Further, the result of the *Hosmer and Lemeshow chi-square test* was significant at the p>0.05 level (χ^2 = 3.73, (8), p=0.88), indicating good model fit.

Regression analysis indicated that six variables (seven variable levels) significantly predicted household food security status (Table 5) as measured by the EU-SILC.

In this model, those who rented accommodation were 83.2% more likely to be FI (OR 1.832, CI 1.09-3.077, p<0.05) than those who own their home outright/live there for free. Those who did not have access to a car/van were approximately 50% more likely to be FI compared to those who did (OR 1.499, CI 1.01-2.221, p<0.05). Those who were unemployed were almost one and a half times as likely to be FI than those who were employed (OR 2.336, CI 1.168-4.672, p<0.05). The relationship between these previous three variables (tenure, access to a car/van, unemployment) and food insecurity is likely to be mediated by income; however, due to lack of a variable relating to income in the dataset, this could not be tested. Regarding self-reported health status, when compared with respondents with 'very good' health, those with 'good' health were almost 70% more likely to be food insecure (OR 1.689, CI 1.075-2.653, p<0.05), and those with 'bad' health were over 100% more likely to be FI (OR 2.026, CI 1.031-3.981, p<0.05). Those who were extremely anxious or depressed were 64.9% more likely (OR 2.649, CI 1.564-4.486, p<0.001) to

be FI, compared to those who were not anxious or depressed. Respondents who were in receipt of benefits had a greater odds of being FI, compared with those who were not (OR 2.111, CI 1.339-3.329, p<0.001).

INSERT TABLE 5 HERE

HFSSM model

The model was a significant improvement to the null model (χ^2 = 274.026 (27), p<0.001) and the overall correct prediction value of the model (93.5%) was slightly higher than that of the EU-SILC model. Approximately 30 per cent (30.2%) of the variation in the dependent variable was accounted for, which is almost twice as high as the equivalent value for the EU-SILC model. Further, the result of the *Hosmer and Lemeshow chi-square test* was significant as the probability was greater than 0.05 (χ^2 = 4.325 (8), p=0.83), indicating good model fit.

Regression analysis indicated that seven variables significantly predicted household food security status (Table 6) as measured by the HFSSM.

INSERT TABLE 6 HERE

Regarding age, those in the youngest (16-24) age group were more than twice as likely to be FI than those in the reference group (OR 3.203, CI 1.357-7.561, p<0.05). Further, those in the oldest (65-74) age group were approximately 70% less likely to be FI than those in the reference group, having a significant OR of 0.303 (CI 0.106-0.863, p<0.05). Those who are unemployed were almost one and a half times more likely than those who are employed to be FI (OR 2.398, CI 1.105-5.202, p<0.05). In this model those who were moderately anxious were 72.2% more likely to be FI (OR 1.722, CI 1.079-2.749, p<0.05), while those who were extremely anxious/depressed had an almost three times greater likelihood of being FI (OR 3.955, CI 2.215-7.059, p<0.001),

than those who were not anxious/depressed. Those with lower health statuses (good, fair, bad, very bad) had greater ORs of being FI than those who self-reported as having 'very good' health. Those with 'bad' and 'very bad' health, however, were approximately three and a half times more likely to be FI, with OR values of 4.52 (CI 1.992-10.257, $p<0.001$) and 4.536 (CI 1.715-11.997, $p<0.01$) respectively, while those with 'fair' and 'good' health were approximately one and a half times more likely to be FI, with OR values of 2.766 (CI 1.378-5.552, $p<0.01$) and 2.248 (CI 1.218-4.15, $p<0.01$) respectively. Regarding number of adults in the household, single person households were almost one and a half times more likely to be FI than the reference group (dual person households) (OR 2.3, CI 1.298-4.074, $p<0.01$). In this model, respondents who rented rather than owned a home had an almost two times greater odds of being FI (OR 2.694, CI 1.341-5.414, $p<0.01$). Respondents who were in receipt of benefits had an almost two and a half times greater odds of being FI than those who did not receive benefits (OR 3.41, CI 1.906-6.098, $p<0.001$).

Discussion

Results from this study revealed that the HFSSM module categorised fewer people as being food insecure than the EU-SILC questions. The literature similarly finds discrepancies between the proportion of a population sample categorised as food secure/food insecure when using different measures (Beacom *et al*., 2020; Kleve *et al*., 2017; McKechnie *et al*., 2018). It was not within the scope of this study to compare the construct validity of the two measures in their ability to measure food insecurity. However, it could be considered that because the HFSSM measures are linked to Radimer *et al.'s* (1990) qualitative work with those in food insecurity, and subsequent conceptual framework of food insecurity, it could be a more accurate representation of food insecurity than the EU-SILC measures. Further, the four EU-SILC food deprivation questions have not been validated as a construct separate to the other questions contained within the EU-SILC survey (Whelan and Maitre, 2006). Conversely, the HFSSM followed a rigorous construction and verification process to assess its suitability to measure food insecurity and to

ensure the sensitivity of the successive questions. This finding therefore appears to lend support to the recent decision to use the HFSSM to measure food insecurity in the UK, and suggests that regions (such as NI and Republic of Ireland) who use the EU-SILC food deprivation questions to approximate food insecurity should reconsider the sufficiency of this approach. It is acknowledged however that there are reasons why the EU-SILC may remain in use in NI, for example, it is a shorter measure than the HFSSM, therefore may be believed to be a more cost-effective measure to include in a population survey, and in addition, continued use of the EU-SILC in NI allows for all-Island comparison of food insecurity prevalence with the Republic of Ireland.

Descriptive statistics showed that over five per cent of those respondents who were employed were also food insecure, indicating that being employed is not indicative of being food secure. This corroborates with the rise in the 'working poor' (Crettaz, 2013; Rahman, 2015), which is often attributed to the changing nature of work i.e. the rise of insecure work and misuse of 'zero-hour' contracts (Lambie-Mumford, 2019), and thus low or uncertain pay. Purdam and Silver (2020) conducted a study with 108 people living in the UK who were experiencing food insecurity, and all were either working part-time on a zero hours contract or in receipt of welfare benefits. There has been an identified lack of research addressing the causes of 'working poverty' (Crettaz, 2013). The current study finding that being employed is not synonymous with being financially secure rationalises future research in this area to inform policy relating to rate of pay and work contracts. Both EU-SILC and HFSSM models associated unemployment with higher odds of food insecurity, which is consistent with the findings of a similar study also carried out in the UK (Loopstra *et al*., 2019), and with the findings of an earlier study in the US (Dharmasena *et al.*, 2016). The employment variable used in quantitative analysis did not differentiate between whether respondents were employed part-time or full time. Had a variable which accounted for both these employment states been available for analysis, findings regarding the nature of work and food insecurity status may have aligned with the rhetoric of the working poor.

This study found that being in receipt of welfare was a significant predictor of food insecurity status. This finding provides a contribution to the literature in corroborating previous studies' suggestions of the linkages between welfare and food insecurity in the UK (Pemberton *et al.,* 2017; Loopstra *et al*., 2018; Purdam and Silver, 2020). Measures introduced in 2016 to mitigate the impact of welfare reform in NI were due to expire in March 2020 (French and McKillop, 2017), but some of these have been extended to offer additional financial support (Department for Communities, 2020). However, those receiving welfare payments who are currently experiencing food insecurity may find their situation worsen once mitigation measures are removed ultimately. Further research on welfare recipients and deprivation indicators (such as food insecurity) is therefore merited to examine whether policymakers should consider a further extension of mitigation measures or a review of the implications of welfare reform.

Findings showed that those who self-identified as having bad health, and those who were moderately-extremely anxious/depressed were more likely to be food insecure. This finding provides a contribution to the literature on financial difficulty and health, previously identified as lacking (French and McKillop, 2017). However, although poor physical and mental health was statistically associated with food insecurity it is unclear whether this association is causal or whether it is a consequence of being food insecure (Butcher *et al*., 2018), and it must be recognised that there are many other compounding factors which could also explain this association (Tevie and Shaya, 2018). Nonetheless, it is known that food insecurity can create new, and exacerbate existing, health problems (Thompson *et al*., 2018; Mattheys *et al*., 2018).

Although certain studies such as Loopstra *et al.* (2019) and Tarasuk *et al.* (2019) found a correlation between education and food insecurity, reporting that those with higher qualifications were less likely to be food insecure, this study did not find a significant relationship between education status and food insecurity. This study finding therefore corresponds with studies such

as Ganhão-Arranhado *et al.* (2018) and Hunt *et al.* (2019) who also did not find education to be a significant predictor of food insecurity. These studies cited were also carried out in developed market economies: the US (Hunt *et al*., 2019), Canada (Tarasuk *et al*., 2019), Portugal (Ganhão-Arranhado *et al*., 2018) and the UK (Loopstra *et al*., 2019). Reinstadler and Ray (2010) discuss how the probability of education level to increase risk of poverty is often weaker in richer economies, perhaps explaining the variation between results in the literature (and in this study) regarding the predictive effect of educational attainment on food insecurity. Further, the NI Health Survey 2014/15 asks the respondent to indicate their educational attainment, however the respondent may not necessarily be the head of household/primary earner, therefore the ambiguity of this question in relation to the reference person may also contribute to the finding that educational attainment is not a significant predictor of food insecurity, and the mixed findings in the literature may also be a result of using data from household surveys with similar methodology/respondent criteria.

Households with only one adult were found to have a greater probability of being food insecure, confirming the rationale that those who do not live in a shared expenditure household will be more likely to experience food insecurity, as they will have less disposable income to spend on commodities such as food (Minas *et al*., 2013). There was no differentiation made in the analysis between single-adult households, and single-adult households with children. Therefore this study could not confirm findings of other studies (Nord, 2009; Lund *et al*., 2018) which have found a link between single parenthood and household food security status. Further, those who were single or divorced/separated/widowed were not found to be significantly more or less likely to be food insecure than those who were married. This disconfirms Loopstra *et al.'s* (2019) finding that those who were single/separated/divorced/widowed had greater odds of being food insecure compared with those who are married/co-habiting. However, it is acknowledged that Loopstra *et al.* (2019) combined those who were single in a variable with those who were separated/divorced/widowed, while this study considered these two groups separately. Therefore,

had these variables been combined they may have produced a significant finding comparable to Loopstra *et al.'s* (2019).

The HFSSM model in this study found that one-adult households had a significantly greater odds (probability) of being food insecure than dual-adult households, or households with three adults or more. Further, despite certain studies, such as Bartfeld and Dunifon's (2006) and Smith *et al.'s* (2017) findings that the number of children in a household increased the odds of food insecurity, the current study did not find the number of children to significantly affect household food insecurity status. This may be because although expenditures such as food are likely to increase the more people in the household, each additional family member cannot be assumed to add an additional amount to the families' expenditure, as certain housing costs are the same regardless of how many people live in the household (Shaefer *et al*., 2018). This finding differed however from previous study results that the presence of children in the home increased the odds ratio of food insecurity (Loopstra *et al*., 2019), and that as the number of children in the household increased, so too did the odds ratio of food insecurity (Bartfeld and Dunifon, 2006).

The literature includes mixed views as to whether being elderly/of pensionable age would make this cohort more or less likely to be food insecure given their fixed-income status juxtaposed with the potential for them to be asset rich but cash poor (Nord and Kantor, 2006; Emery *et al*., 2013; Leroux *et al*., 2018). Quantitative results however did not find the oldest age groups to be more likely to be food insecure than the most prevalent age group of respondents (45-54 year olds) who were selected as the reference group. Under the HFSSM, results found that 16-24 year olds had a greater odds ratio of being food insecure than those in the reference group. Loopstra *et al.* (2019) also used the 45-54 age group as a reference when conducting a logistic regression to assess predictors of food insecurity using the HFSSM on a sample of England, Wales and NI. Loopstra *et al.'s* (2019) study similarly found that those in both the 16-24 and 25-34 year old age groups had a significantly higher odds of food insecurity than those in the 45-54 year age (reference)

group. Further, Loopstra *et al.'s* (2019) finding that those in the 65+ age group had a lower probability of food insecurity than those in the reference group was also replicated in this study.

Single mother households have been found in the literature to be more susceptible to food insecurity (Nord, 2009; Martin and Lippert, 2012), due to the burden of care and full household responsibility preventing them from taking up employment outside of the home (Ruspini, 1998). Quantitative analysis however examined independent variables and their contribution to the dependent variable separately, rather than combining variables such as gender and marital status to test household types such as single mother households. Therefore this demographic was not tested in the current study. Gender was not found to be significantly associated with food insecurity in this study, according with Loopstra et al's (2019) UK study findings, but differing from Broussard's (2019) international study which found that females across regions have a greater probability of being food insecure than males.

The finding that renting rather than owning the home/living there rent-free was a significant predictor of food insecurity on both models is consistent with findings in the literature e.g. Bartfeld and Dunifon (2006). This association is presumably connected to disposable income, as those who rent will need to account for the cost of their monthly rent being deducted from their monthly household income, and therefore will have proportionally less disposable income to spend on food and other necessities than those who own their home outright.

Policy implications

Findings relating to the sensitivity of the EU-SILC versus the HFSSM in identifying the prevalence of household food insecurity in a population, and identifying predictors, are relevant for policymakers in those countries which use the EU-SILC and/or HFSSM measures to assess levels of household food insecurity in the population, as they can inform their decisions related to continuing use of these measures. Findings regarding the predictors of household food

insecurity are relevant not only to policymakers in UK/NI where this study was conducted, but also across the EU and other developed nations such as North America, as those predictors identified to be significant in this study have general common agreement with similar studies in other developed regions globally. Specific findings which may be of particular interest with regards to policy decision making are those relating to the associations between being in receipt of welfare and the occurrence of food insecurity among those households where the household head was employed. These issues are of particular prominence in light of the recent cessation/modification of welfare mitigation measures in NI; Brexit; and COVID-19. In these uncertain economic times, it is possible that the Government will be open to reviewing and putting in place policies to protect the most vulnerable. However, it is also acknowledged that Government spending and budgets are likely to be more cautious coming out of the COVID-19 pandemic, in a bid to recoup spending occurred during the crisis (e.g. business grants and income support schemes). Any policy decisions with regards to helping deprived households will need to be informed by robust evidence, therefore further research in this area is recommended.

Limitations

Although this study indicates a preference for the HFSSM as opposed to the EU-SILC, this research did not undertake a process of comparing the reliability or validity of both measures, so cannot conclusively state a 'best' measure. Further, as the full HFSSM measure was not used in the dataset, and as the EU-SILC food deprivation questions are not validated as a separate construct, respondents cannot be definitively categorised or compared as being food secure / food insecure. Regarding predictors, due to dataset limitations it is acknowledged that there are further individual and household demographic factors which have been identified in the literature as predictors of food insecurity which were not examined in this study, such as race and income, or household typologies such as single mother households. Further, it is important to note that these predictors are not necessarily causal and it is unclear whether these factors were present prior to the food insecurity experience or whether they are a consequence of it, indicating an exacerbation of their circumstances. Lastly, the scope of this research focused only on comparing two current

food insecurity indicators used in NI, suggesting one as more suitable than the other. However, it is acknowledged that there are other food security indicators and approaches to assessing the food environment, which may provide additional use as an important lever in influencing and implementing policy that is sensitive to local conditions, such as Community Food System Assessments (Jacobson, 2007).

Conclusions

This research confirmed other studies' findings that different measures will categorise food security status differently. The EU-SILC classified slightly more respondents as food insecure than the HFSSM (8.3% versus 6.5%, respectively), however the literature indicates that the HFSSM has greater sensitivity of analytical capability, therefore suggesting that HFSSM classification of food insecurity prevalence may be more reliable. Further, considering both overall model fit statistics, and individual variable test results, it appears that the HFSSM model is a better fit than the EU-SILC model, accounting as it does for more of the variation and displaying greater evidence of statistical significance among predictors. With regards to assessment of food security in NI, findings from this study indicate that the HFSSM may be a more suitable indicator than the EU-SILC, a suggestion further supported by the decision to use the HFSSM as the agreed food security measure in the UK. Both modules (HFSSM and EU-SILC) identified the variables relating to tenure, employment status, health status, anxiety/depression and receipt of benefits to be predictors of food insecurity. Alternate predictors identified as significant by the HFSSM were age and number of adults in the household. An additional predictor identified as significant by the EU-SILC was not having household access to a car. These findings therefore provide a contribution in extending literatures which have examined predictors in other countries and contexts, and confirms and disconfirms (in the NI context, and in the context of a developed nation's population) various predictors of food insecurity. Findings can inform policy action with regards to targeting the key contributors, and can inform policy decisions in NI and elsewhere with regards to choosing the most appropriate food insecurity indicator.

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