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Version: Accepted Version

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**Article:**

Loopstra, Rachel, Reeves, Aaron and Tarasuk, Valerie (2019) The rise of hunger among low-income households: an analysis of the risks of food insecurity between 2004 and 2016 in a population-based study of UK adults. *Journal of Epidemiology and Community Health*, 73 (7). pp. 668-673. ISSN 0143-005X

<https://doi.org/10.1136/jech-2018-211194>

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**The rise of hunger among the unemployed and the disabled: an analysis of the risks of food insecurity between 2004 and 2016 in a population based study of UK adults.**

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Word count: 3,000

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## **Abstract**

### *Background*

Rising food bank use in the past decade in the UK raises questions about whether food insecurity has increased. Using the 2016 Food and You survey, we describe the magnitude and severity of the problem, examine characteristics associated with severity of food insecurity, and examine how vulnerability has changed among low-income households by comparing 2016 data to the 2004 Low Income Diet and Nutrition Survey.

### *Methods*

The Food and You survey is a representative survey of adults living in England, Wales, and Northern Ireland (n=3,118). Generalised ordered logistic regression models were used to examine how socio-economic characteristics related to severity of food insecurity. Coarsened exact matching was used to match respondents to respondents in the 2004 survey. Logistic regression was used to examine if food insecurity rose between survey years.

### *Results*

20.7% (95% CI: 18.7 to 22.8%) of adults experienced food insecurity in 2016, and 2.72% (95% CI: 2.07 to 3.58%) were severely food insecure. Younger age, non-White ethnicity, low education, disability, unemployment, and low income were all associated with food insecurity, but only the latter three characteristics associated with severe food insecurity. Controlling for socio-economic variables, the probability of low-income adults being food insecure rose from 27.7% (95% CI: 24.8 to 30.6%) in 2004 to 45.8% (95% CI: 41.6 to 49.9%) in 2016. The rise was most pronounced for people with disabilities.

### *Conclusions*

Food insecurity affects economically deprived groups in the UK, but unemployment, disability, and low income are characteristics specifically associated with severe food insecurity. Vulnerability to food insecurity has worsened among adults with disabilities since 2004.

## **Introduction**

Household food insecurity, defined in high-income countries as “the uncertainty and insufficiency of food availability and access that are limited by resource constraints, and the worry or anxiety and hunger that may result from it” [1], is a critical determinant of health. Children growing up in food insecure homes have poorer health and education outcomes [2-4] than children growing up in food secure homes. Food insecure adults experience high rates of depression and anxiety, use more mental health care services [5-8], are more likely to have inadequate nutrient intakes [9], and cost public healthcare systems more than food secure adults [10].

The alarming rise in food bank usage in the UK in recent years has pushed the health consequences of food insecurity back onto the public health agenda. In the Trussell Trust Foodbank Network, the only UK food bank organisation tracking usage nationwide and which supports a franchised network making up about 60% of UK food banks, food parcel distribution rose from about 61,500 in 2010-11 to 1.33 million in 2017-18 [11], a rise linked with welfare reforms [12].

Yet, monitoring food insecurity, and understanding its drivers, using food bank data is problematic. Food banks were largely unavailable before 2010, only beginning to proliferate since then [13]. Food bank data also does not capture food insecure people who do not receive help from food banks [14]. This discrepancy comes through clearly in data from the Gallup World Poll, which, in 2014, showed the number of people experiencing food insecurity is 17 times larger than the number of people seen in Trussell Trust food banks [15]. A critical, but unexplored, question for Britain is, has food insecurity risen or has the new availability of food banks simply revealed food insecurity in the population?

Answering this question is difficult because food insecurity is not regularly measured in the UK, though some surveys have included food insecurity at different times. In this study, we begin by describing the magnitude and severity of food insecurity among specific socio-economic groups using data from the Food and You (F&Y) survey, collected in 2016 [16]. We then compare these data with the 2004 Low Income Diet and Nutrition Survey (LIDNS) [17]. Since certain groups are over-represented in food banks (such as the unemployed, those unable to work due to disabilities, and families with children) [18], we use these surveys to provide information on who is at risk of food insecurity today, and how this compares to risk in 2004, providing insight into how this problem has changed over a period of economic recession, austerity, and welfare reform in the UK [19, 20].

## **Methods**

### *Data*

The 2016 F&Y survey was a cross-sectional survey of 3,118 adults aged 16+ living private dwellings in England, Wales, and NI [16]. Fieldwork was conducted over

Summer 2016. Details of the sampling method and survey procedures are available in the user guide [21].

The 2004 LIDNS targeted the most deprived households in the UK. Doorstep screening was used to recruit households who were materially deprived (according to questions concerning car ownership, tenancy, receipt of means-tested benefits, employment status, lone parent status) and, in ambiguous cases, household income. In total, 3,728 individuals were included in the final sample. Details on the survey methodology are available in the survey report [22].

### *Measurement and classification of food insecurity*

Household food insecurity is experienced on a continuum, ranging from experiences of food running out to going whole days without eating [23]. These experiences are captured in the US Department of Agriculture 10-item Adult Food Security module (see Web Appendix 1), a validated tool for measuring food insecurity in high-income countries [24], which was used in the 2016 F&Y and the LIDNS. We coded food insecurity using methods adopted by researchers in Canada [25], which denotes moderate food insecurity as two or more affirmative responses and severe food insecurity, as six or more affirmative responses. Marginal food insecurity denotes one question answered affirmatively. Food secure means no questions were answered affirmatively. Respondents missing responses to any of the questions could not be scored and were excluded (n= 6).

### *Predictor variables*

Using variables available in the F&Y survey (see Web Appendix 1), we examined whether food insecurity was associated with: position in the income distribution (i.e. income quartile) after adjusting for household size, presence of children, respondent age, gender, marital status, employment status, life-limiting disability or illness, ethnicity, education level, country, and rural/urban dwelling. F&Y data specifically identify households with children under 6 so we also differentiate between households with and without young children because having younger children may differentially relate to food insecurity than having only older children. Across these variables, a total of 35 respondents were missing data and excluded from analyses. The 665 respondents who did not report their income quartile were included as a separate level of the income variable.

### *Analysis*

All analyses were conducted using Stata version 15 survey procedures, providing weighted estimates of population proportions and tests of association corrected for sampling design.

Associations between household characteristics and the 4-level food insecurity variable were analysed using a generalised ordered logistic regression model [26], which allows effect sizes to vary for each interval change in the outcome. This model simultaneously estimates odds ratios for three comparisons: (1) the food secure *versus* all food insecurity

categories; (2) people who are marginally food insecure or food secure *versus* people experiencing moderate and severe food insecurity; (3) people who are not in severe food insecurity *versus* people who are in severe food insecurity.

We first estimate the association between socio-economic characteristics and food insecurity excluding position in the income distribution because it is a mediating variable and thereby potentially biases our results [27]. But, we explore how our results change once income quartile is added, testing whether these socio-economic characteristics continue to associate with risk of food insecurity across different levels of income.

#### *Combining the F&Y survey with the LIDNS*

The 2004 LIDNS was merged with the 2016 F&Y survey, but because these samples were not designed to be combined we have excluded some respondents to make these datasets more comparable. First, we only included those respondents in the F&Y sample from the lowest income quartile (n=335) so that these respondents are more similar to the materially deprived LIDNS sample. Second, we excluded LIDNS respondents in Scotland and under 16 years of age to match the F&Y sample. These samples are quite similar in terms of age, ethnicity, and the prevalence of disabilities (see Web Appendix 2) but less so in terms of education and employment status, partly because LIDNS was exclusively targeted at the most deprived households.

This imbalance could lead to biased estimates when comparing food insecurity between the two surveys because the populations could differ too much to make reliable comparisons. Thus, we used a partial matching approach called Coarsened Exact Matching [28] to match respondents on the same variables from the F&Y analysis (albeit with some variables slightly modified, see Web Appendix 3): household income, employment status, long-standing illness or disability, age, gender, presence of children in household, household size, marital status, ethnicity, region, and any education qualifications. Whilst recently developed, this matching procedure has been applied in various public health settings [29-31] because it is effective at reducing the imbalances observed in the raw data above (more details on the matching are available in Web Appendix 4). Matching can mean the analytic sample is no longer representative of the underlying population and so estimates may not be generalised to the whole population. Due to small sample sizes, we dichotomise food insecurity for these analyses (fully food secure versus food insecure) and estimate the probability of any food insecurity among households in 2004 and 2016 using logistic regression models. Interaction terms were used to test if vulnerability to food insecurity changed between survey years for groups over-represented in food banks in 2016 [18], namely people with disabilities, children, and without work.

## **Results**

### *How many people are food insecure and which groups are most at risk?*

Almost 21% of adults in England, Wales, and NI experienced some level of food insecurity in 2016. Based on adult population size for these countries, this equates to, 10,242,000 adults. Figure 1 shows prevalence estimates for each level of food insecurity.

[Figure 1 about here]

Unadjusted prevalence rates across socio-demographic characteristics are shown in Table 1. Food insecurity prevalence and severity decreased with age and differed across ethnic groups, with those not identifying as White having higher rates of all levels of food insecurity. Single, divorced, separated or widowed adults also had significantly higher levels of food insecurity. About 30% of adults with children less than 16 years of age were food insecure, significantly higher than adults without children. Far more adults were moderately or severely food insecure in the bottom income quartile, and the same was true of those with less education. Food insecurity was elevated among adults who were unemployed or economically inactive. Adults with a disability or illness that reduced their activities of daily living also had higher rates of food insecurity. Food insecurity did not differ across countries, though urban areas had higher rates of marginal and moderate food insecurity.

[Table 1 about here]

#### *Multivariate analysis of the risk and severity of food insecurity*

Table 2 presents results from the generalised ordered logistic regression model. Here, after accounting for other factors, respondents in the 16 to 24 and 25 to 34 age group had significantly higher odds of any (but not severe) food insecurity compared to respondents in the 45 to 54 age group. Respondents in the 65+ age group had significantly lower odds of any food insecurity and severe food insecurity, even after adjusting for income quartile.

Adults who did not identify as White had significantly higher odds of any (but not severe) food insecurity. Gender and marital status did not significantly relate to any level of food insecurity in the multivariate model. However, the odds of experiencing any level of food insecurity were significantly higher if there were children in the home.

[Table 2 about here]

Socio-economic variables remained strongly correlated with food insecurity. Lower levels of education were associated with higher odds of any level of food insecurity and also increasing severity of food insecurity. For example, having a higher degree or postgraduate qualifications was associated with significantly lower odds of experiencing higher levels of food insecurity, even after adjusting for income quartile.

Unemployment was associated with high odds of any level of food insecurity, and the odds increased in magnitude for more severe forms of food insecurity. For unemployed respondents, the odds ratio for severe food insecurity was 4.17 (95%CI: 1.3-12.8) even after adjustment for income quartile. The same was broadly true for people who were not working for reasons other than retirement, but this association was greatly reduced with the addition of income quartile to the model (OR: 2.03, 95%CI: 0.79-5.20).

Long-term health problems or a disability, particularly conditions which reduced daily activities a lot, was strongly associated with food insecurity, even after accounting for employment status. Moreover, the relationship between serious disabilities and health problems and food insecurity became increasingly stark for the most severe levels of food insecurity. This pattern among people living with a disability was not explained by their position in the income distribution.

Lastly, people in lowest quartile of the income distribution were far more likely to experience any form of food insecurity and were also more likely to experience moderate and severe food insecurity (Table 2).

#### *Comparison to risk factors for food insecurity in 2004*

The probability of food insecurity among low-income adults increased between 2004 and 2016. As shown in figure 2, for the average low-income respondent, the predicted probability of being food insecure in 2004 was 27.7% (95%CI: 24.8 to 30.6%), whereas, for the average low-income respondent in the 2016 sample, this rose to 45.8 (95%CI: 41.6% to 49.9%), suggesting the prevalence of food insecurity almost doubled among low-income households over this period (see Web Appendix 5 for full set of logistic regression models).

[Figure 2 about here]

Food insecurity for people with ill-health or living with a disability changed considerably over this period. Food insecurity rose from 37.7% (95%CI: 32.0 to 43.4%) in 2004 to 53.5% (95%CI: 47.7 to 59.3%) in 2016. As shown in figure 3, this rise was significantly greater than that observed for households without disabilities, suggesting food insecurity rose to a significantly greater extent for households with disabilities ( $p$  for interaction term: 0.009).

[Figure 3 about here]

We saw no clear change in food insecurity among those who were retired, and perhaps even a slight decline (13.2% in 2004 and 12.01% in 2016). However, food insecurity seemed to rise among those in work from 46.7% in 2004 to 59.3% in 2016, though confidence intervals overlap (Web Appendix 6). Similarly, there was also a substantial, though not statistically significant, increase in the predicted probability of food insecurity from 50.6% in 2004 to 69.3% amongst the unemployed and those not working for other reasons. The probability being food insecure among respondents with children also rose from 51.6% in 2004 to 64.7%, but this rise did not differ from the rise observed for respondents without children.

#### **Discussion**

This study provides the only examination of how vulnerability to food insecurity has changed for those socio-economic characteristics commonly associated with rising food



bank use, namely, unemployment, disability, and children. The 2016 F&Y survey documents the scale of food insecurity across England, Wales, and NI: one in five adults were worried about or directly experienced inadequate access to food, which is about 10.2 million adults. Younger adults, adults with children, ethnic minorities, and adults with low levels of education all faced higher risks of food insecurity. Food insecurity was both incredibly common and severe among adults who were unemployed and those who had life-limiting illnesses or disabilities. Unsurprisingly, the richest households had the lowest chance of experiencing food insecurity.

The second key contribution of this paper, beyond describing the problem today, is revealing the changing level of food insecurity among low-income households. Between 2004 and 2016, food insecurity increased 18.1 percentage points among low-income adults across England, Wales, and NI, with a marked rise for adults who were living with long-standing illnesses or disabilities, a pattern potentially explained by welfare reform. The Great Recession may have also exacerbated food insecurity in this groups but this seems unlikely because by 2016 the UK was no longer in recession and poverty rates were actually lower than they were in 2004. By contrast, welfare reform had continued, the effects of which were keenly felt by those with long-standing illnesses [19, 32].

There are important limitations to our study. First, though we use a robust matching method to explore changing vulnerability to food insecurity in the UK, longitudinal data would have been preferable. Second, richer data on income, assets, and employment would have enabled a more precise description how economic resources and the nature of employment (e.g. part-time work, zero-hour contracts) affect vulnerability to food insecurity [33]. The crude income data and lack of deprivation measures in F&Y meant the precision of our matching procedure was limited and unobserved confounders could bias our analysis of changes in food insecurity over time. However, if anything, our results are likely biased toward *under-estimating* the increase between 2004 and 2016 because the 2004 sample was likely more materially deprived than the 2016 sample, where we could only restrict to the lowest income quartile. Material deprivation is closely related to food insecurity [34, 35], so we would expect the 2004 sample to have higher food insecurity rates for this reason. Yet, we still observed a marked increase in the 2016 sample compared to the 2004 sample. Finally, matching approaches can reduce the representativeness of analytic samples, which means these results should not be inferred to a wider population. However, in the absence of other representative data sources, our approach provides the best estimates available of the change in food insecurity among poor households. Further, the limitations of our analysis strongly support calls for ongoing monitoring of food insecurity in the UK population (e.g. the Food Insecurity Bill which is due to have its 2<sup>nd</sup> reading in Parliament in late March 2019) [36]. Importantly, the Department for Work and Pensions has recently decided that as of 2019/20 [37], a 30-day measure of food insecurity will be added to the Family Resources Survey. These data will enable ongoing monitoring of the risk and magnitude of food insecurity over time going forward.

Food bank data have been repeatedly but problematically used to describe food insecurity in the UK. Food banks primarily serve people who are severely food insecure and who

are unemployed or living with an illness [18]. Similarly, we observed food insecurity, particularly severe food insecurity, is more common among the unemployed and those with disability. But, our analysis also reveals the scale of food insecurity is larger than food bank data suggest. The Trussell Trust Foodbank Network (accounting for ~2/3 of food banks), distributed 1.04 million food parcels in England, Wales, and NI in 2016/17 [38] to approximately 321,500 adults (see Web Appendix 7 for calculation). This is less than 1/20th of food insecure adults estimated in this study. Food banks may be inaccessible to some people who are food insecure because of policies (such as the Trussell Trust's requirement for clients to have a referral) [39]. Even as a proportion of severely food insecure adults, our estimates suggest Trussell Trust food parcels only reach about one quarter of these adults.

Food insecurity is linked to poor health [5, 7, 8, 10]. In part this is because poor health predisposes people to be at risk of food insecurity and our analysis has observed that those groups most at risk of food insecurity, namely people with low incomes, who are unemployed or who are living disabilities, are also those groups who are already at risk of poor health [40]. Notwithstanding these selection effects, food insecurity is also an independent predictor of worsening health, suggesting that the increased prevalence of food insecurity among these groups will likely contribute to widening health inequalities. Here, then, is another way in which welfare reform – which has disproportionately affected these same groups – is potentially exacerbating economic and social inequalities [13, 41-43]. The rising vulnerability to food insecurity observed between the 2004 LIDNS and F&Y survey suggests that the poorest in the UK are worse off today. Food insecurity has certainly always existed in the UK but, in light of the welfare changes that occurred over this period, it is possible the current social security system is providing increasingly inadequate protection from food insecurity for more and more people.

## Summary box

*What is already known on this subject?*

- The rapid rise in food bank use in the UK since 2010 has raised concern about household food insecurity, but little is known about risk factors for this problem in the population.
- Understanding who is vulnerable and whether food insecurity has increased for particular groups is critical for design of effective interventions.

*What this study adds?*

- Based on new analyses of national survey data for 2016 and comparing these to data from 2004, this study identifies that adults who are unemployed or who have life-limiting disabilities are at increased risk of severe food insecurity in the UK and that their vulnerability has increased since the last national study.
- As a key social determinant of health, the increasing vulnerability of these groups to food insecurity means health inequalities may widen for these groups.

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Table 1 Household food insecurity by household socio-demographic characteristics.

	Food secure n=2431	Marginal food insecurity n=231	Moderate food insecurity n=298	Severe food insecurity n=119	p value
Gender					0.1127
Men	81.2%	7.88%	8.98%	1.98%	
Women	77.6%	7.60%	11.4%	3.43%	
Age					<0.0001
16-24	63.7%	12.9%	17.6%	5.83%	
25-34	72.0%	11.2%	12.9%	3.88%	
35-44	76.0%	8.29%	12.9%	2.77%	
45-54	80.9%	5.88%	10.6%	2.65%	
55-64	85.6%	5.16%	7.39%	1.84%	
65-74	91.6%	3.90%	3.75%	---	
75+	92.3%	5.83%	1.80%	---	
Ethnicity					0.0007
White	81.4%	6.74%	9.25%	2.58%	
Other ethnic group	66.5%	13.9%	16.0%	3.62%	
Marital status					<0.0001
Married/cohabiting	82.8%	6.93%	8.42%	1.87%	
Single/Widowed/Divorced/Separated/Other	73.6%	9.08%	13.2%	4.15%	
Children under 6 in household					<0.0001
No	81.3%	7.23%	9.24%	2.72%	
Yes	68.3%	10.7%	15.7%	5.32%	
Children under 16 in the household					<0.0001
No	83.2%	6.30%	8.40%	2.08%	
Yes	70.0%	11.2%	14.5%	4.28%	
Education					<0.0001
No qualifications identified	74.8%	8.43%	12.6%	4.15%	
O level/GCSE, CSE, NVQ/SVQ/GSVQ level 2 or below <sup>1</sup>	71.8%	8.87%	15.1%	4.16%	

Diplomas in higher education/other HE qualifications <sup>2</sup>	79.6%	6.84%	10.5%	3.02%	
Degree (undergrad, including B.Ed.) and postgrad diplomas/certifications <sup>3</sup>	86.1%	5.43%	7.01%	1.43%	
Higher degree or postgraduate qualifications	87.3%	9.27%	3.19%	---	
Other qualifications (including overseas)	70.8%	18.1%	10.3%	---	
Household income					<0.0001
<£10,399	59.8%	9.09%	16.5%	14.7%	
£10,400-£25,999	69.1%	9.47%	17.4%	4.10%	
£26,000-£51,999	82.4%	9.05%	7.46%	---	
>£52,000	90.7%	3.96%	5.10%	---	
Missing	79.4%	8.41%	9.92%	2.24%	
Work status					<0.0001
In work	80.9%	7.58%	10.1%	1.45%	
Retired	91.5%	4.75%	3.32%	0.48%	
Unemployed	46.5%	13.9%	20.5%	19.2%	
Other	61.1%	11.7%	19.1%	8.14%	
Long-term health problem/disability					<0.0001
None/no impact on daily activities	80.6%	7.95%	9.64%	1.82%	
Yes, reduces daily activities a little	75.6%	6.14%	13.4%	4.82%	
Yes, reduces daily activities a lot	70.0%	7.76%	11.7%	10.5%	
Region					0.0719
England	79.6%	7.6%	10.17%	2.64%	
Wales	74.4%	10.7%	11.84%	3.04%	
Northern Ireland	78.7%	8.29%	8.15%	4.89%	
Urban/rural classification					0.0319
Urban	78.1%	8.12%	11.0%	2.80%	
Rural	84.7%	6.10%	6.78%	2.39%	

Notes: Data are weighted sample proportions. (---) proportions not disclosed due to small sample size. P values are for Chi square statistic.

<sup>1</sup> Includes GNVQ intermediate or foundation and BTEC



<sup>2</sup> HNC/HND/BTEC Higher Teaching qualifications for schools/further education, A/AS levels/SCE, Higher/Scottish Cert 6th Year Studies, NVQ/SVQ/GSVQ level 3  
ONC/OND/BTEC National, City, Trade apprenticeships.

<sup>3</sup> Includes professional qualifications at degree level, NVQ/SVQ.

Table 2 Odds of increasing severity of food insecurity by household socio-demographic characteristics in England, Wales, and Northern Ireland, 2016.

	Fully food secure vs. marginal/moderate/severe food insecurity		Fully food secure/marginal vs. moderate/severe food insecurity		Fully food secure/marginal/moderate vs. severe food insecurity	
	Model 1	Model 2 (income adjusted)	Model 1	Model 2 (income adjusted)	Model 1	Model 2 (income adjusted)
	OR	OR	OR	OR	OR	OR
<b>Gender</b>						
Men	Ref	Ref	Ref	Ref	Ref	Ref
Women	1.23 (0.93-1.62)	1.19 (0.90-1.58)	1.34 (0.93-1.93)	1.28 (0.90-1.81)	1.71 (0.77-3.82)	1.56 (0.70-3.49)
<b>Age</b>						
16-24	<b>1.94 (1.03-3.67)</b>	<b>2.09 (1.11-3.93)</b>	1.61 (0.80-3.23)	1.69 (0.82-3.50)	2.18 (0.91-5.24)	2.27 (0.87-5.90)
25-34	<b>1.76 (1.16-2.69)</b>	<b>1.65 (1.06-2.57)</b>	1.52 (0.97-2.38)	1.48 (0.90-2.43)	1.41 (0.65-3.06)	1.52 (0.59-3.90)
35-44	1.34 (0.90-1.99)	1.30 (0.86-1.95)	1.39 (0.84-2.32)	1.22 (0.69-2.17)	0.98 (0.49-1.93)	0.89 (0.42-1.88)
45-54	Ref	Ref	Ref	Ref	Ref	Ref
55-64	0.71 (0.47-1.08)	0.68 (0.45-1.02)	0.62 (0.36-1.06)	<b>0.55 (0.31-0.98)</b>	0.46 (0.20-1.07)	0.43 (0.18-1.06)
65+	<b>0.31 (0.14-0.71)</b>	<b>0.28 (0.12-0.65)</b>	<b>0.14 (0.03-0.66)</b>	<b>0.12 (0.02-0.69)</b>	<b>0.09 (0.01-0.61)</b>	<b>0.07 (0.01-0.46)</b>
<b>Self-assigned ethnicity</b>						
White British/White	Ref	Ref	Ref	Ref	Ref	Ref
Other/mixed ethnicity	<b>1.81 (1.17-2.82)</b>	<b>1.68 (1.08-2.60)</b>	1.51 (0.80-2.85)	1.31 (0.72-2.40)	2.07 (0.91-4.73)	1.59 (0.73-3.46)
<b>Marital status</b>						
Married/cohabiting	Ref	Ref	Ref	Ref	Ref	Ref

Single/Widowed/Divorced/Separated/Other	1.20 (0.80-1.82)	1.05 (0.68-1.61)	1.14 (0.71-1.82)	1.03 (0.62-1.72)	0.93 (0.46-1.86)	0.81 (0.41-1.62)
<b>Children in household</b>						
No children in household	Ref	Ref	Ref	Ref	Ref	Ref
Children under 16, but none under 6	<b>2.00 (1.30-3.06)</b>	<b>1.74 (1.13-2.69)</b>	1.23 (0.63-2.39)	1.01 (0.49-2.06)	2.55 (0.62-10.5)	2.21 (0.52-9.40)
Children under 6 and possibly older children	<b>2.20 (1.38-3.53)</b>	<b>1.64 (1.00-2.71)</b>	1.79 (0.88-3.67)	1.25 (0.58-2.71)	<b>4.31 (1.27-14.6)</b>	2.84 (0.69-11.8)
<b>Qualifications</b>						
No qualifications identified	<b>3.04 (1.88-4.93)</b>	<b>2.46 (1.52-3.98)</b>	<b>3.33 (1.74-6.39)</b>	<b>2.71 (1.31-5.57)</b>	<b>3.36 (1.13-10.02)</b>	2.75 (0.79-9.49)
O level/GCSE, CSE, NVQ level 2 or below <sup>1</sup>	<b>2.71 (1.80-4.10)</b>	<b>2.22 (1.49-3.30)</b>	<b>2.38 (1.38-4.10)</b>	1.86 (0.99-3.47)	2.00 (0.75-5.37)	1.63 (0.53-5.01)
Diplomas in higher education <sup>2</sup>	<b>1.72 (1.15-2.57)</b>	1.45 (0.97-2.16)	<b>1.78 (1.01-3.14)</b>	1.49 (0.81-2.74)	1.94 (0.63-6.01)	1.61 (0.44-5.83)
Undergrad degree/postgraduate diplomas <sup>3</sup>	Ref	Ref	Ref	Ref	Ref	Ref
Higher degree/postgraduate qualifications	0.89 (0.52-1.52)	1.10 (0.64-1.89)	<b>0.36 (0.15-0.84)</b>	<b>0.40 (0.16-0.98)</b>	<b>0.11 (0.02-0.61)</b>	<b>0.17 (0.03-0.93)</b>

Other qualifications (including overseas)	<b>2.86 (1.31-6.24)</b>	<b>2.58 (1.15-5.77)</b>	1.37 (0.49-3.81)	1.09 (0.40-2.98)	0.52 (0.05-5.93)	0.51 (0.04-6.19)
<b>Work status</b>						
In work	Ref	Ref	Ref	Ref	Ref	Ref
Retired	0.82 (0.40-1.66)	0.74 (0.37-1.49)	0.97 (0.25-3.78)	0.80 (0.18-3.64)	1.04 (0.23-4.83)	1.06 (0.22-5.13)
Unemployed	<b>2.84 (1.67-4.83)</b>	<b>2.09 (1.24-3.52)</b>	<b>2.93 (1.76-4.89)</b>	<b>2.02 (1.23-3.33)</b>	<b>7.21 (3.37-15.4)</b>	<b>4.17 (1.36-12.8)</b>
Other	<b>1.54 (1.03-2.30)</b>	1.38 (0.91-2.11)	<b>1.62 (1.01-2.59)</b>	1.30 (0.83-2.05)	<b>3.03 (1.52-6.01)</b>	2.03 (0.79-5.20)
<b>Long-term health problem/disability</b>						
None/no impact on daily activities	Ref	Ref	Ref	Ref	Ref	Ref
Yes, reduces daily activities a little	<b>1.52 (1.05-2.21)</b>	1.41 (0.99-2.02)	<b>1.65 (1.08-2.52)</b>	<b>1.69 (1.07-2.65)</b>	1.98 (0.95-4.13)	1.92 (0.89-4.15)
Yes, reduces daily activities a lot	<b>2.17 (1.41-3.32)</b>	<b>1.98 (1.30-3.03)</b>	<b>2.64 (1.62-4.31)</b>	<b>2.62 (1.63-4.20)</b>	<b>6.54 (3.04-14.0)</b>	<b>6.06 (2.92-12.6)</b>
<b>Region</b>						
England	Ref	Ref	Ref	Ref	Ref	Ref
Wales	<b>1.53 (1.13-2.08)</b>	1.35 (0.98-1.88)	1.09 (0.76-1.55)	0.94 (0.63-1.40)	1.05 (0.56-2.00)	0.91 (0.46-1.81)
Northern Ireland	1.09 (0.78-1.51)	0.99 (0.71-1.39)	0.87 (0.59-1.30)	0.77 (0.50-1.18)	1.00 (0.50-2.01)	0.89 (0.41-1.94)
<b>Urban/rural classification</b>						
Urban	Ref	Ref	Ref	Ref	Ref	Ref

Rural	0.82 (0.56-1.20)	0.82 (0.58-1.16)	0.77 (0.51-1.16)	0.70 (0.46-1.07)	1.07 (0.56-2.04)	1.03 (0.51-2.07)
<b>Household income</b>						
<£10,399	---	<b>5.03 (2.69-9.39)</b>	---	<b>5.18 (2.32-11.6)</b>	---	<b>16.1 (2.49-103.5)</b>
£10,400- £25,999	---	<b>4.32 (2.77-6.77)</b>	---	<b>4.03 (2.12-7.66)</b>	---	<b>7.80 (2.28-26.7)</b>
£26,000- £51,999	---	1.94 (1.26-3.00)	Ref	1.28 (0.66-2.46)	Ref	3.04 (0.84-11.0)
>£52,000	---	Ref	---	Ref	---	Ref
Missing	---	1.69 (1.04-2.74)	---	1.52 (0.77-3.01)	---	<b>4.65 (1.17-18.4)</b>

*Notes: Odds ratios from a generalised ordered logistic model and SEs adjusted for complex survey design. Models adjusted for household size to adjust household income by size but not shown.*

Figure 1 Prevalence of marginal, moderate and severe food insecurity among adults in England, Wales, and Northern Ireland, 2016.

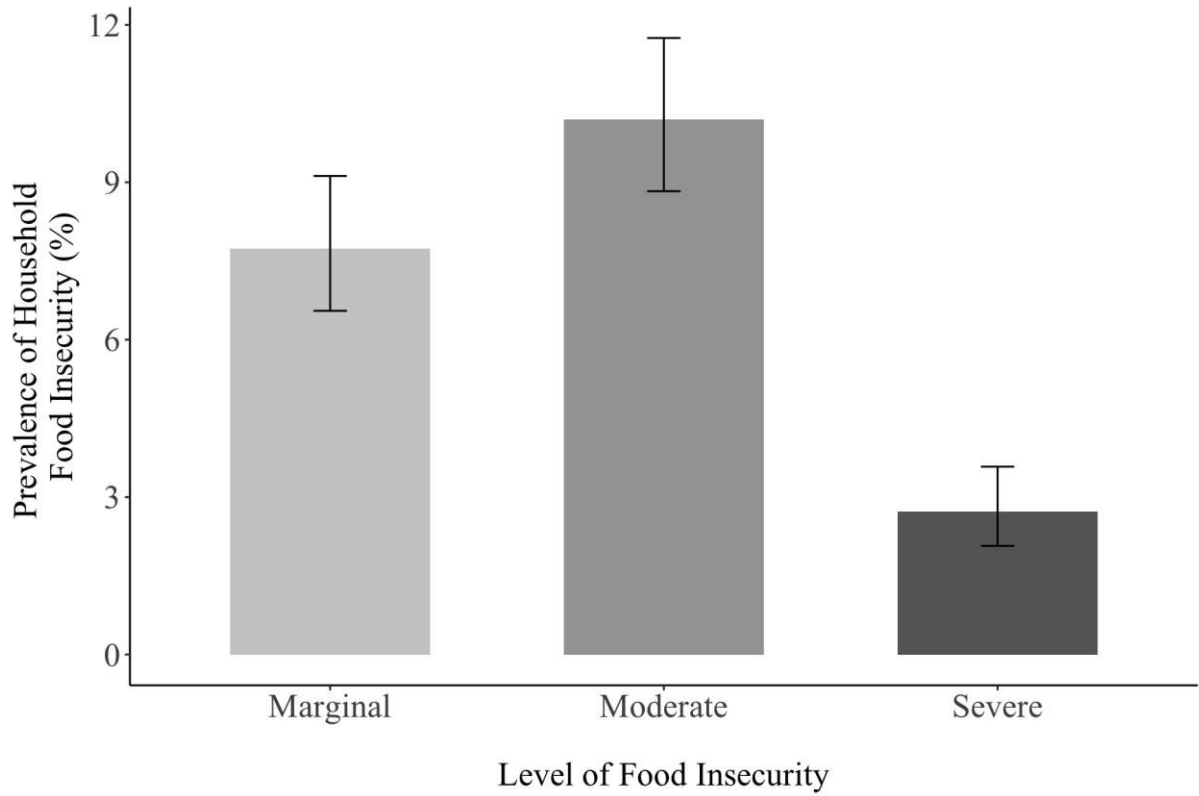
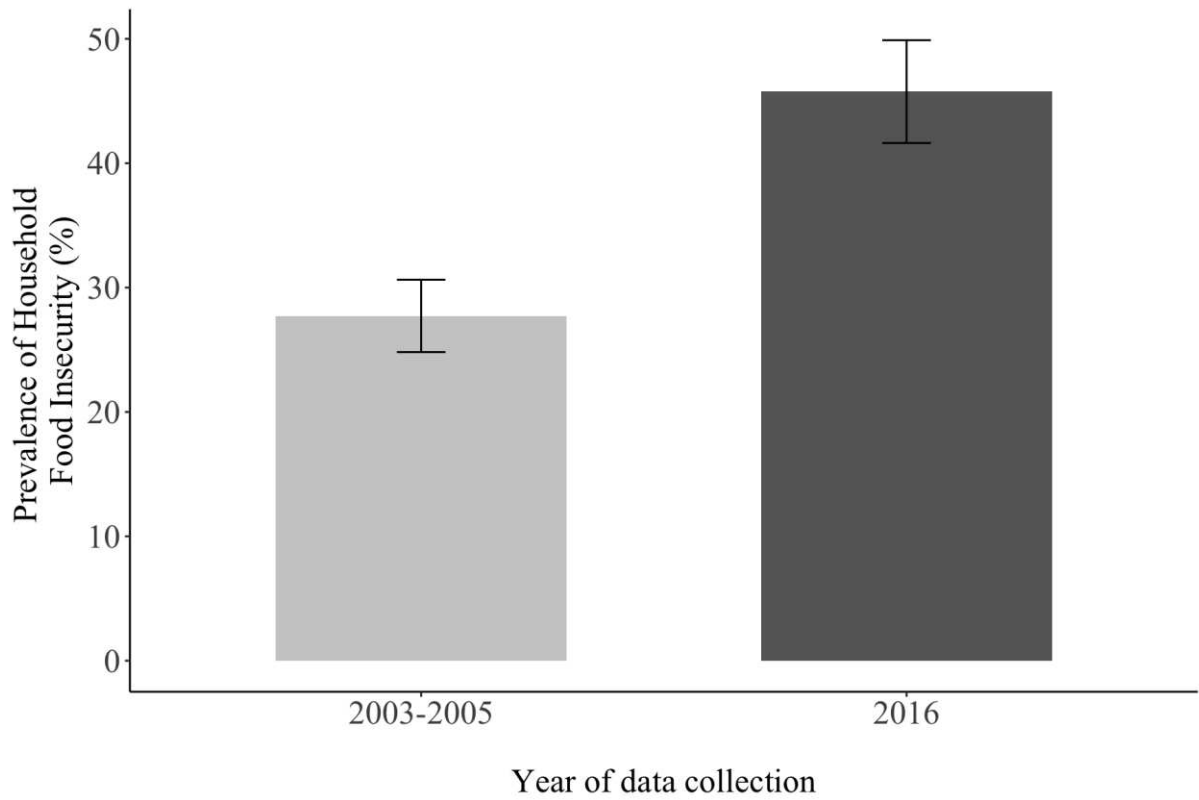
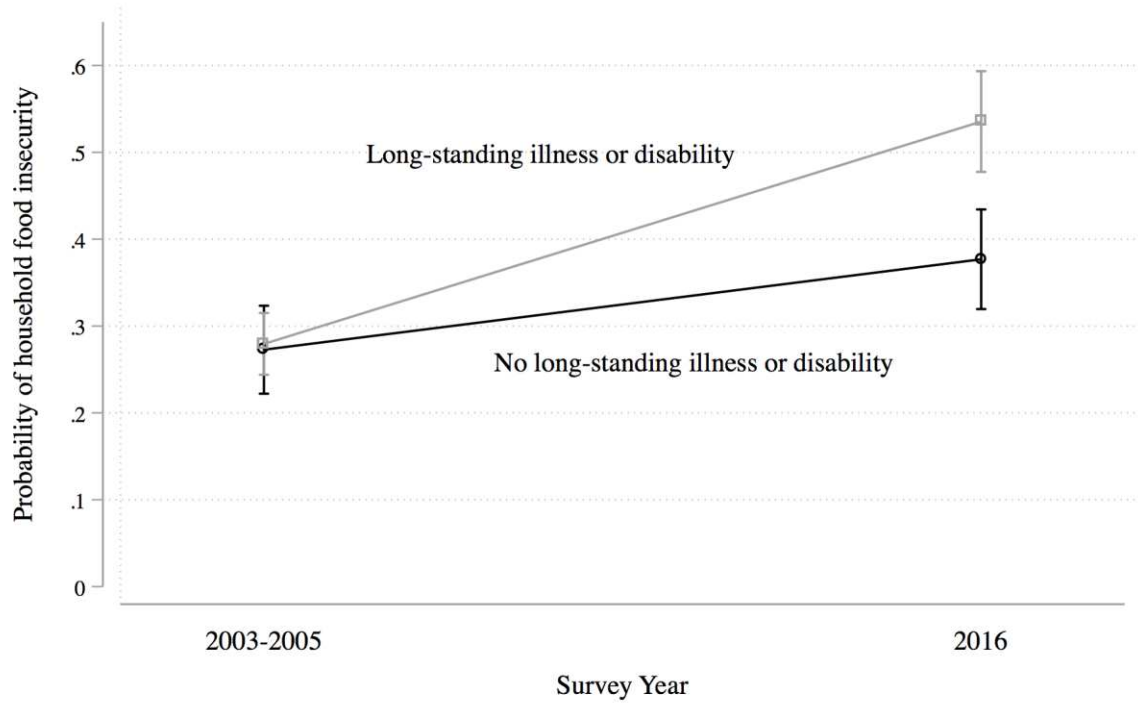


Figure 2 Predicted probability for lowest income groups in England, Wales, and Northern Ireland in 2003-2005 versus 2016.



Notes: Data are a matched sample of participants from the 2003-2005 Low Income Diet and Nutrition Survey (LIDNS) and 2016 Food and You Survey.

Figure 3 Probability of food insecurity by disability status for lowest income groups in England, Wales, and Northern Ireland in 2003-2005 versus 2016.





## **Web Appendix**

**Web Appendix 1** USDA Adult Food Security Survey Module and Survey Variables

**Web Appendix 2** Comparison of sample characteristics between Low Income Diet and Nutrition Survey (2003-2005) and adults in the lowest income quartile from Food and You Survey (2016).

**Web Appendix 3** Variables used in analyses of Food and You Survey (2016) and modifications necessary to combine with Low Income Diet and Nutrition Survey (2003-2005).

**Web Appendix 4** Description of the matching procedure

**Web Appendix 5** Logistic regression analyses comparing odds of food insecurity in 2003-2005 to 2016.

**Web Appendix 6** Probability of food insecurity by employment status for lowest income groups in England, Wales, and Northern Ireland in 2003-2005 versus 2016.

**Web Appendix 7** Estimates of the proportion of food insecure adults helped by Trussell Trust food banks in England, Wales, and Northern Ireland

## Web Appendix 1: USDA Adult Food Security Survey Module and Survey Variables

### USDA Adult Food Security Survey Module<sup>1</sup>

These next questions are about the food eaten in your household in the last 12 months, since (current month) of last year and whether you were able to afford the food you need.		
Stage 1: In the last 12 months, can you tell me if these statements were true for you?		
1	“We worried whether our food would run out before we got money to buy more.”	Often true Sometimes true Never true
2	“The food that we bought just didn’t last, and we didn’t have money to get more.”	Often true Sometimes true Never true
3	“We couldn’t afford to eat balanced meals.”	Often true Sometimes true Never true
Stage 2 (if one or more Stage 1 Adult/Household questions affirmed): In the last 12 months...		
4a	Did (you/you or other adults in your household) ever cut the size of your meals or skip meals because there wasn't enough money for food?	Yes No
4b	If yes: How often did this happen—almost every month, some months but not every month, or in only 1 or 2 months?	Almost every month Some months but not every month Only 1 or 2 months
5	Did you ever eat less than you felt you should because there wasn't enough money for food?	Yes No
6	Were you every hungry but didn't eat because there wasn't enough money for food?	Yes No
7	Did you lose weight because there wasn't enough money for food?	Yes No
Stage 3 (if one or more Stage 2 Adult/Household questions affirmed): In the last 12 months...		
8a	Did (you/you or other adults in your household) ever not eat for a whole day because there wasn't enough money for food?	Yes No
8b	If yes: How often did this happen—almost every month, some months but not every month, or in only 1 or 2 months?	Almost every month Some months but not every month Only 1 or 2 months

Source: <https://www.ers.usda.gov/topics/food-nutrition-assistance/food-security-in-the-us/measurement/>

Web Appendix 2: Sample characteristics of adults in Low Income Diet and Nutrition Survey (2003-2005) and adults in the lowest income quartile from Food and You Survey (2016).

	F&Y (n=3,100)	F&Y- bottom income quartile only (n=334)	LIDNS (n=2465)	p value
Gender				0.294
	Male	39.6	36.5	33.6
	Female	60.4	63.5	66.4
Age				<0.0001
	16-24	7.14	7.8	10.4
	25-34	13.5	9.6	15.1
	35-44	15.3	11.4	17.0
	45-54	16.8	19.8	13.6
	55-64	17.3	14.1	15.0
	65+	30.1	37.4	28.9
Ethnicity				0.94
	White	91.9	92.2	92.3
	Other ethnic group	8.08	7.78	7.67
Any educational qualifications				<0.0001
	No	20.9	39.8	61.3
	Yes	79.1	60.2	38.7
Marital status				<0.0001
	Married/cohabitating	54.4	16.8	32.7
	Single/Widowed/Divorced/Separated/Other	45.6	83.2	67.3

Long-term health problem/disability					0.436
	No	63.7	45.2	43.0	
	Yes	36.4	54.8	57.0	
Work status					<0.0001
	In work	50.7	19.8	12.3	
	Retired	32.1	39.2	28.9	
	Unemployed/Other	17.3	41.0	58.8	
Children under 16 in the household					<0.0001
	Yes	25.5	19.2	34.2	
	No	74.5	80.8	65.8	
Household size					<0.0001
	One	30.0	62.0	35.7	
	Two	36.0	20.7	33.1	
	Three	15.0	9.6	15.2	
	Four or more	19.0	7.8	16.1	
Region					<0.0001
	England	67.7	62.9	73.2	
	Wales	15.7	18.0	13.2	
	Northern Ireland	16.5	19.2	13.6	

*Notes:* Data are unweighted sample proportions. Sample restricted to respondents with non-missing values for all variables. Food and You survey respondents only include those in bottom income quartile. P value for chi square.

**Web Appendix 3** Variables used in analyses of Food and You Survey (2016) and modifications necessary to combine with Low Income Diet and Nutrition Survey (2003-2005).

<b>Variables used in analysis of Food and You Survey</b>	<b>Modifications to match Food and You Survey to Low Income Diet and Nutrition Survey</b>
<b>Gender</b>	No modifications.
Men	
Women	
<b>Age</b>	Only respondents aged 16+ from LIDNS survey included. Continuous age variable from LIDNS coded into age ranges.
16-24	
25-34	
35-44	
45-54	
55-64	
65+	
<b>Self-assigned ethnicity</b>	No modifications.
White British/White	
Other/mixed ethnicity	
<b>Marital status</b>	No modifications.
Married/cohabiting	
Single/Widowed/Divorced/Separated/Other	
<b>Children in household</b>	Only binary variable indicating whether or not any children under 16 included in combined analysis.
No children in household	
Children under 16, but none under 6	
Children under 6 and possibly older children	
<b>Qualifications</b>	Multiple levels of education provided in both surveys collapsed into an indication of any qualifications or none.
No qualifications identified	
O level/GCSE, CSE, NVQ level 2 or below <sup>1</sup>	
Diplomas in higher education <sup>2</sup>	
Undergrad degree/postgrad diplomas <sup>3</sup>	
Higher degree/postgraduate qualifications	
Other qualifications (including overseas)	
<b>Work status</b>	LIDNS categories indicated were: working, in full-time education, or not working at present.
In work	No modifications.
Retired	In LIDNS, if indicated not working at present and respondent retirement age, classified as retired to match Food and You survey.
Unemployed	All unemployed and not working for other reasons in Food and You combined with not

	working for other reasons and adults in full-time education in LIDNS, with exception of respondents of retired age (as above)
Other	See above.
<b>Long-term health problem/disability</b>	Additional information on impact on daily activities not available in LIDNS.
None/no impact on daily activities	Changed to binary question - long standing illness or disability or none, regardless of impact on daily activities.
Yes, reduces daily activities a little	Information not included in combined analysis.
Yes, reduces daily activities a lot	Information not included in combined analysis.
<b>Region</b>	Respondents from LIDNS in Scotland excluded to match sample from Food and You.
England	LIDNS: 9 regions in England combined into one category.
Wales	None
Northern Ireland	None
<b>Urban/rural classification</b>	Not available in LIDNS. Not included in combined analysis.
Urban	
Rural	
<b>Household income</b>	
<£10,399	Only adults from lowest income quartile from Food and You Survey included in combined analysis.
£10,400-£25,999	
£26,000-£51,999	
>£52,000	
Missing	
<b>Household size</b>	LIDNS values up to 10. Reduced to match Food and You categories.
1	
2	
3	
4	
5+	

#### Web Appendix 4: Description of the matching procedure

Coarsened Exact Matching (CEM) is a partial matching procedure. There were only 335 respondents in the Food and You that were in the bottom quartile of the income distribution whereas the Food and You survey contained 2608 respondents (2,943 matched respondents in total). Our matching procedure found matches for 239 respondents in the Food & You data (trimming 96 respondents). These were ‘matched’ with 923 respondents from the LIDNS data (trimming 1685 respondents).

CEM splits all variables into bins or categories and we simply allow these bins or categories to reflect the pre-defined categories of all the variables included in the model (e.g., male and female). We match respondents on the following variables: employment status, long-standing illness or disability, age, gender, presence of children in household, household size, marital status, ethnicity, region, and any education qualifications

Adding all these variables together creates 1107 different possible combinations (or strata) and the CEM algorithm seeks to match the LIDNS survey data to those strata (or combinations) where respondents from the Food & You survey are found. Only 116 strata have matched individuals. It is possible to have more than one match in each strata and so the matching is weighted to reflect the uneven distribution of the data across these strata. CEM is usually assessed using a global fit statistic  $\zeta_1$  (or  $L_I$ ). This fit statistic tells us how imbalanced the data sets are before the matching procedure (1 = completely separable or no-overlap while 0 = perfectly balanced).

In our analysis, before the matching procedure,  $\zeta_1$  is 0.907 while after the matching procedure  $\zeta_1$  has fallen to 0.665, which we regard as a significant improvement. If we look at the differences between specific variables we can see that on some variables the matching has been somewhat successful, removing some of the differences between the distribution of these variables (e.g., Work Status and Disability). On most variables the degree of imbalance was already low and so matching has made little difference (e.g., Gender, Children in Household, Household Size, Marital Status, Region, and Ethnicity). On one variable it has been less successful and may have slightly increased imbalance in our education variable, but this is offset by the gains elsewhere. The matching is not perfect, of course, but CEM is by definition an improvement over the imbalance observed in the raw data.

Web Table A3: Balance between key covariates before and after matching

Variable	Variable specific measure of imbalance ( $\zeta_x$ )	Difference in means before matching	Difference in means after matching
Work status	0.232	-0.843	-0.132
Age	0.305	0.179	-0.512
Long-term health problem/disability	0.168	-0.214	-0.168

Gender	0.031	-0.076	0.031
Children under 16 in the household	0.002	-0.078	-0.002
Household size	0.058	0.058	0.126
Marital status	0.083	-0.236	0.083
Ethnicity	0.039	-0.008	0.039
Region	0.019	0.103	0.295
Any educational qualifications	0.468	0.425	0.468

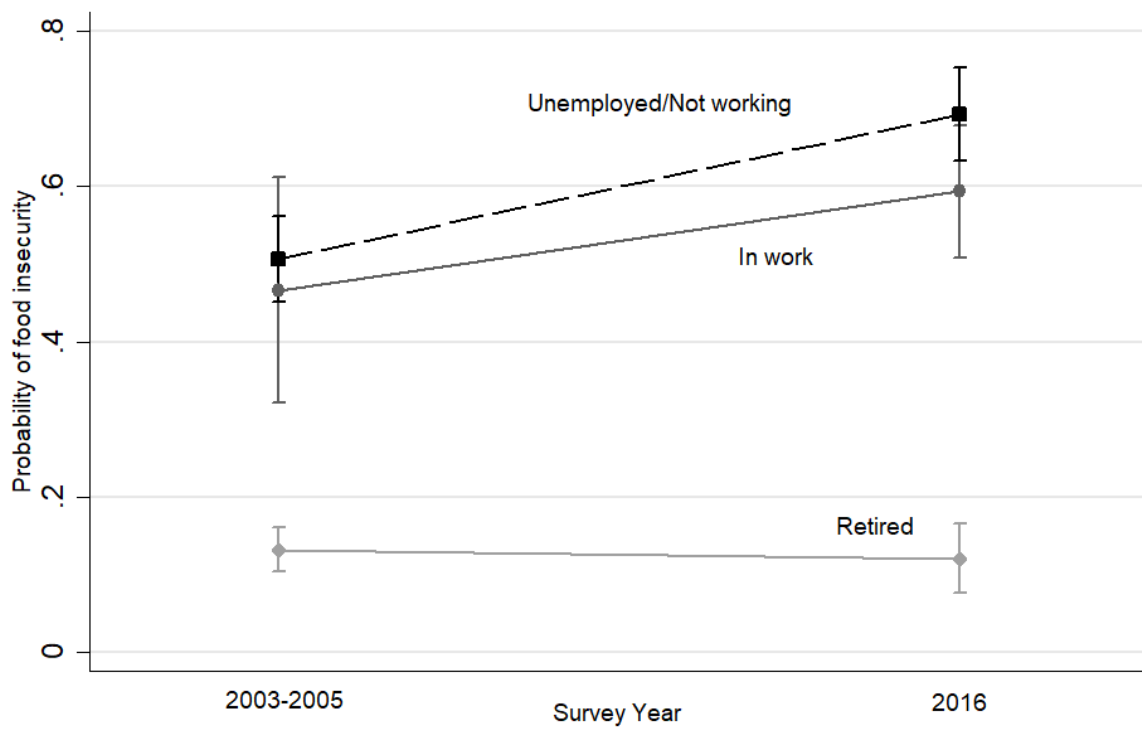


Web Appendix 5: Logistic regression analyses comparing odds of food insecurity in 2003-2005 to 2016.

	Food insecurity (Odds Ratio (95% CI))			
	(1)	(2)	(3)	(4)
Survey year				
2003-2005	Referent	Referent	Referent	Referent
2016	<b>2.20 (1.76-2.7)</b>	<b>1.67 (0.84-3.31)</b>	<b>2.38 (1.87-3.04)</b>	<b>1.61 (1.13-2.30)</b>
Employment status				
In work	---	Referent	---	---
Retired	---	0.17 (0.09-0.33)	---	---
Unemployed or Other	---	1.17 (0.63-2.19)	---	---
Retired*2016 interaction term	---	0.54 (0.23-1.25)	---	---
Unemployed/other*2016 interaction term	---	1.32 (0.61-2.85)	---	---
Any children <16				
No	---	---	Referent	---
Yes	---	---	3.39 (2.30-5.00)	---
Children*2016 interaction term	---	---	0.72 (0.38-1.37)	---
Long standing illness or disability				
No	---	---	---	Referent
Yes	---	---	---	1.03 (0.76-1.41)
Illness/disability*2016 interaction term	---	---	---	<b>1.84 (1.16-2.92)</b>
Observations	1,147	1,147	1,147	1,147

Notes: Logistic regression models adjusted for sample characteristics using coarsened exact matching. Matching criteria include employment status, age, disability, gender, any children, household size, marital status, ethnicity, country, and any qualifications.

Web Appendix 6: Probability of food insecurity by employment status for lowest income groups in England, Wales, and Northern Ireland in 2003-2005 versus 2016.



Notes: Data are a matched sample of participants from the 2003-2005 Low Income Diet and Nutrition Survey (LIDNS) and 2016 Food and You Survey. Matching criteria include employment status, age, disability, gender, any children, household size, marital status, ethnicity, country, and any qualifications.

## Web Appendix 7: Estimates of the proportion of food insecure adults helped by Trussell Trust food banks

Based on the [nomis.co.uk](http://nomis.co.uk) data on the number of adults living in England, Wales, and Northern Ireland in 2016 (n=48,769,174), we estimate that about 10.2 million adults experience some level of food insecurity in the UK (this is, based on the estimate of 21% of people who are food insecure). Based on the prevalence of severe food insecurity (2.72%), an estimated 1,326,521 adults are severely food insecure.

In 2016/17, The Trussell Trust distributed 746,016 food parcels to adults in England, Wales, and NI in 2016/17 (see regional breakdown data available from <https://www.trusselltrust.org/news-and-blog/latest-stats/end-year-stats/#fy-2016-2017>). These data are not a count of unique individuals, however. The Trussell Trust estimates that people receive about two food parcels each, on average, so we divide 746,016 by two to estimate that about 324,053 adults received help from Trussell Trust food banks in 2016/17.

Thus, the proportion of food insecure adults in England, Wales, and Northern Ireland who could have accessed Trussell Trust food banks is:  $324,053/10,241,526$ , which is 3.1%. As a proportion of severely food insecure adults, (i.e.  $324,053/1,326,521$ ), possibly about 24.4% could have received help from Trussell Trust food banks.