

## RESEARCH

# The effect of rising food prices on food consumption: systematic review with meta-regression

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Rosemary Green *research fellow*<sup>1,2</sup>, Laura Cornelsen *research fellow*<sup>2,3</sup>, Alan D Dangour *senior lecturer*<sup>1,2</sup>, Rachel Turner *honorary research fellow*<sup>1</sup>, Bhavani Shankar *professor of international agriculture, food and health*<sup>2,4</sup>, Mario Mazzocchi *associate professor*<sup>5</sup>, Richard D Smith *professor of health system economics*<sup>2</sup> *dean*<sup>3</sup>

<sup>1</sup>Faculty of Epidemiology and Population Health, London School of Hygiene and Tropical Medicine, London, UK; <sup>2</sup>Leverhulme Centre for Integrative Research on Agriculture and Health, London, UK; <sup>3</sup>Faculty of Public Health and Policy, London School of Hygiene and Tropical Medicine, London, UK; <sup>4</sup>Centre for Development, Environment and Policy, School of Oriental and African Studies, London, UK; <sup>5</sup>Department of Statistical Sciences, University of Bologna, Bologna, Italy

## Abstract

**Objective** To quantify the relation between food prices and the demand for food with specific reference to national and household income levels.

**Design** Systematic review with meta-regression.

**Data sources** Online databases of peer reviewed and grey literature (ISI Web of Science, EconLit, PubMed, Medline, AgEcon, Agricola, Google, Google Scholar, IdeasREPEC, Eldis, USAID, United Nations Food and Agriculture Organization, World Bank, International Food Policy Research Institute), hand searched reference lists, and contact with authors.

**Study selection** We included cross sectional, cohort, experimental, and quasi-experimental studies with English abstracts. Eligible studies used nationally representative data from 1990 onwards derived from national aggregate data sources, household surveys, or supermarket and home scanners.

**Data analysis** The primary outcome extracted from relevant papers was the quantification of the demand for foods in response to changes in food price (own price food elasticities). Descriptive and study design variables were extracted for use as covariates in analysis. We conducted meta-regressions to assess the effect of income levels between and within countries on the strength of the relation between food price and demand, and predicted price elasticities adjusted for differences across studies.

**Results** 136 studies reporting 3495 own price food elasticities from 162 different countries were identified. Our models predict that increases in the price of all foods result in greater reductions in food consumption in poor countries: in low and high income countries, respectively, a 1%

increase in the price of cereals results in reductions in consumption of 0.61% (95% confidence interval 0.56% to 0.66%) and 0.43% (0.36% to 0.48%), and a 1% increase in the price of meat results in reductions in consumption of 0.78% (0.73% to 0.83%) and 0.60% (0.54% to 0.66%). Within all countries, our models predict that poorer households will be the most adversely affected by increases in food prices.

**Conclusions** Changes in global food prices will have a greater effect on food consumption in lower income countries and in poorer households within countries. This has important implications for national responses to increases in food prices and for the definition of policies designed to reduce the global burden of undernutrition.

## Introduction

Food prices are a primary determinant of consumption patterns, and high food prices may have important negative effects on nutritional status and health, especially among poor people.<sup>1</sup> The global food price crisis of 2007-08 focused international attention on the effect of changes in food price on nutrition and health. Estimates from the United Nations Food and Agriculture Organization suggest that in 2008 an additional 40 million people were pushed into hunger by the global rise in cereal prices,<sup>2-4</sup> and evidence is accumulating that dietary diversity and quality have been negatively affected by food price rises, particularly among the poorest.<sup>5</sup> In contrast, the governments of wealthy countries are increasingly adopting fiscal measures that change the relative price of foods to promote healthy diets.<sup>6,7</sup> Simulation studies have suggested that imposing taxes on foods such as sugar sweetened beverages<sup>8,9</sup> or foods high in saturated

Correspondence to: R Green Faculty of Epidemiology and Population Health, London School of Hygiene and Tropical Medicine, London WC1E 7HT, UK [rosemary.green@lshtm.ac.uk](mailto:rosemary.green@lshtm.ac.uk)

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Supplementary information

fats and salt<sup>10 11</sup> could result in reductions in obesity and cardiovascular mortality, although because of a lack of relevant data the actual impact of such taxes on different population subsections is largely unknown.

Fiscal approaches to control tobacco use have identified that responsiveness to raised tobacco prices is higher in low income countries and among poorer households who spend a greater relative share of their income on tobacco.<sup>12</sup> Similar information on the differing response to food price changes by national and household income level is needed to help with the identification of food price policies to protect population health. A recent report by the Food and Agriculture Organization identified the absence of a robust evidence base with which to guide policies on food price,<sup>13</sup> and important questions remain concerning the impact of changes in food prices on food consumption, especially in poor populations.<sup>14</sup>

Several studies of the relation between the price of a given food and demand for that food, known as “price elasticities” (see box) have been conducted, but as yet few attempts have been made to synthesise this literature.<sup>15-17</sup> Currently no systematic review of the empirical evidence on the relations between food prices and demand at a global level has been done, and no study has explored whether these relations differ between income groups within the same country.

## Methods

A study protocol was prespecified and made available online ([www.lshtm.ac.uk/eph/dph/research/nutrition/research/agriculture/systematic\\_review\\_protocol.pdf](http://www.lshtm.ac.uk/eph/dph/research/nutrition/research/agriculture/systematic_review_protocol.pdf)).

## Study selection and search strategy

Using a prespecified list of search terms (see supplementary file) we conducted a systematic search with an end date of 15 August 2011 of six relevant databases: ISI Web of Science, EconLit, PubMed, Medline, AgEcon, and Agricola. We also searched other online resources, including Google, Google Scholar, Ideas REPEC, Eldis, and the websites of the US Department of Agriculture, Food and Agriculture Organization, World Bank, and International Food Policy Research Institute. We included papers in the peer reviewed or grey literature with English abstracts using data from 1990 onwards. Two authors (RG and LC) independently conducted the literature search and identified relevant papers. RG and LC then checked all included abstracts and disagreements were resolved after discussion. Abstracts and full texts were screened for inclusion according to prespecified criteria:

## Inclusion criteria

We considered studies to be eligible for inclusion if they were nationally representative cross sectional, cohort, experimental, or quasi-experimental studies presenting food price elasticities using data from household level surveys (for example, household expenditure surveys or national food surveys), national aggregate data (for example, food price and food availability data collated by national governments), or supermarket/home scan data (for example, consumer purchasing data generally collected by market research companies), collected after 1990 and disaggregated by food group. We only included studies examining retail prices of food items (not, for example, live animal or nutrient prices), those where price elasticities were calculated using multiple equation methods (for example, Almost Ideal Demand System or similar, see supplementary table S1), and those using uncompensated price elasticities

(which also incorporate the indirect effect on consumption induced by the change in available budget generated by the price change).

## Data extraction

We compiled a database of all the included studies using Microsoft Access and included information on own price elasticities, that is, the elasticity of demand for foods with respect to the food’s own price (including standard errors and statistical significance where these were available); study type; data source; years of data available; country of study; number of observations (where available); statistical methods used; and whether sociodemographic variables were included in the models. We assessed the quality of the included studies using a prespecified eight item checklist of information provided in the paper: data source, data representativeness, number of observations (where appropriate), statistical methods used, food groupings, statistical significance of the estimates, how price data were obtained, and how demand data were obtained. Papers meeting all eight criteria were considered high quality.

Over 40 different food groupings were used in the included studies, and we subsequently produced our own groupings of foods according to those most commonly presented in the included studies and in line with US Department of Agriculture guidelines.<sup>18</sup> The nine food groups used in our analyses were fruit and vegetables; meat; fish; dairy; eggs; cereals; fats and oils; sweets, confectionery, and sweetened beverages; and other food. Three authors (RG, LC, and RT) extracted the data, and a different coauthor (RG, LC, and RT) independently checked a random sample of 10% of all the extracted studies for errors.

## Statistical analysis

We tabulated descriptive statistics for the studies included in the review. To investigate whether study characteristics affected the size of the food price-demand relation we constructed meta-regression models in MLwiN (Version 2.25: Centre for Multilevel Modelling, University of Bristol). The models used random effects to account for multiple estimates coming from the same study (and also to account for multiple studies coming from the same country), and also used 50 bootstrap repetitions to obtain more robust standard errors for the resulting coefficients. We used these meta-regression models to calculate predicted price-demand relations for each food group, and for countries with different income levels. Outputs of these models take the form of the predicted percentage change in demand associated with a 1% increase in the price of each food. We performed sensitivity analysis excluding those studies not graded as high quality. Finally, we performed a prespecified separate analysis on those studies that had reported relations for different income groups. In this analysis we constructed another meta-regression model including all the previously used variables, but also comparing people in the highest income category with those in the lowest income category to determine whether the price-demand relation was different for different income groups within the same country.

All regression analyses included study methods (function and estimation type used in the models), whether the study was published in a peer reviewed journal, the type of data (whether aggregate, cross sectional, panel, or scanner data), and the mean year of data collection as covariates. The covariates were identified through the use of a directed acyclic graph<sup>19</sup> (see supplementary figure S1).

We report our findings in accordance with the PRISMA statement (see supplementary file).<sup>20</sup>

### Food price elasticity

The relation between demand for a given food and its own price among consumers is known as the "own price elasticity of demand." These elasticities are coefficients that describe the percentage by which the demanded quantity of a food changes in response to a 1% increase in the price of the food. The coefficients are calculated by dividing the percentage change in the quantity demanded by the percentage change in the price and are usually derived as part of econometric models known as "demand systems." The most common form of these models is the AIDS (Almost Ideal Demand System),<sup>20</sup> of which there are many variations (see supplementary table S1). This type of model is a system of equations that considers the allocation of total available budget into the expenditure for different foods (or other goods) as a function of total expenditure and prices.

Own price elasticity of demand is usually negative, because demand almost always decreases as prices increase. However, the magnitude of the elasticity may be larger or smaller depending on the availability and closeness of substitute foods, necessity of the food, the proportion of budget spent on it, and the time period. All of these factors can be included in the demand system models.

For example, confectionery tends to have larger elasticities, as for most people it is not a necessity and also has a relatively high price, thus requiring a larger proportion of the available budget. Dietary staples, such as cereals, tend to have smaller elasticities, because these foods are necessities in the diet, are usually cheaper, and people conserve their income for spending on such essentials when prices increase. In a similar way, low income countries tend to have higher price elasticities for all foods than high income countries, because food represents a large share of total income in these countries, hence price changes have a larger impact on budget allocation.

## Results

Our original search identified 1482 studies, of which 888 met our inclusion criteria based on screening of abstracts (figure 1). When we screened the full texts of these 888 studies, 158 studies met the inclusion criteria, and we included 136 studies that reported uncompensated price elasticities in our review.

### Characteristics of included studies

The included studies reported a total of 3495 estimates of uncompensated food price elasticities from 162 countries (table 1). The largest number of estimates came from Europe and Asia, and almost half were from low income countries. More than two thirds of estimates came from the grey literature, and over half came from national aggregate data.

### Differences between food groups and country income levels

Predicted price elasticities from the meta-regression models identify clear and robust trends by country income level: demand for all food groups was more responsive to changes in price in lower income than higher income countries (table 2). The highest predicted price elasticities (represented by the largest negative coefficients) were found for meat (−0.78, 95% confidence interval −0.83 to −0.73), fish (−0.80, −0.85 to −0.74), dairy (−0.78, −0.84 to −0.73), and other food (−0.95, −1.01 to −0.90) in low income countries, whereas the lowest were found for cereals (−0.43, −0.48 to −0.36) and fats and oils (−0.42, −0.48 to −0.35) in high income countries. The low predicted price elasticity for eggs was based on a relatively small number of observations (see table 1). Sensitivity analysis including only high quality studies (n=40) did not substantially alter these findings.

### Differences between household income groups

We repeated our meta-regression models for the subset of 21 studies (with 355 estimates) that reported relations between food prices and demand for different income groups within the same countries and compared the highest income group with the lowest reported in each study. The 21 included studies were more likely than those in our country level analysis to report data from high income countries and to have used data from supermarket scanner surveys, from which price elasticity estimates are generally larger, because of the higher level of disaggregation of this type of data.

Our analysis identified that demand for food was more responsive to price changes among households with lower incomes (table 3). The highest elasticities were found for meat (−0.95, 95% confidence interval −1.07 to −0.82), fish (−1.01,

−1.17 to −0.84), and other food (−1.06, −1.21 to −0.92) among low income households, and the lowest were found for cereals (−0.72, −0.85 to −0.59), sweets (−0.73, −0.91 to −0.55), and fruit and vegetables (−0.73, −0.84 to −0.62) among high income households. The differences in elasticities between income groups were largest in high income countries, but were also substantial in low income countries (data shown in supplementary table S3).

## Discussion

The relation between food prices and demand is stronger for all food groups in low income countries than in high income countries, indicating that increases in food prices are likely to have a disproportionately greater impact on food consumption in low income countries. Food prices also had a stronger impact on demand for food in lower income households within countries—a relation that has not been explored in previous reviews. Irrespective of national wealth category, the elasticities of dietary staples such as cereals and fats and oils were lower than those of animal source foods (meat, fish, and dairy), suggesting that in all settings, animal source foods represent luxury foods in the human diet. These estimates allow us for the first time to quantify the likely impact of global rises in food prices on demand for food in households and countries with different wealth profiles.

### Applications of findings

This is the first review to quantify systematically the relation between food prices and demand for food worldwide, and the first to explore differences in this relation between household income groups. To demonstrate the value of the elasticities presented, we estimated the effect of price changes on presumed consumption (as estimated from Food and Agriculture Organization data on food availability). Food and Agriculture Organization food availability data are a proxy for national level food consumption that have been shown to correlate with other measures of food intake and health outcomes.<sup>21 22</sup> Based on our predicted price elasticities, a 10% increase in the global price of cereals would reduce demand for cereals by 6.1% in low income countries and 4.3% in high income countries, equivalent to 301 kJ (72 kcal) and 167 kJ (40 kcal) reductions on average in cereal availability per person per day in low and high income countries, respectively. The estimated 75% greater reduction in low income countries in demand for cereals that often form the predominant part of the diet shows the unequal impacts of global changes in food prices. Our analysis also suggests that poorer people in low income countries will suffer the most and highlights that higher food prices may substantially increase their risks of undernutrition. For wealthy countries aiming to use taxes and subsidies beneficially to influence dietary patterns,

the analyses suggest that compared with low income countries the influence of food prices on demand is attenuated and that household income will largely determine the effectiveness of such strategies at a population level.

### Strengths and weaknesses of this study

This review has many strengths, including its systematic and exhaustive nature and the inclusion of peer reviewed and grey literature. Given the diverse nature of studies included we went to significant efforts to allow for the heterogeneity of the data and methods included in our analysis. We also conducted a sensitivity analysis to determine whether differences in study quality might have affected our results. This showed that restricting the analysis to high quality studies only (which were overwhelmingly peer reviewed studies) made little difference to the relations found. Previous studies have attempted such a review for US studies alone<sup>15</sup> and for studies of meat and fish,<sup>23 24</sup> but none have attempted this for all food groups worldwide. In addition, although worldwide data from single sources summarising relations between food prices and demand are available, these tend to be based on aggregate data only that do not allow for differences by income level.<sup>21</sup>

Limitations of the study relate largely to the study inclusion criteria and data availability. We limited our review to studies analysing data collected from 1990 onwards, as the relation between food prices and demand may have changed over time (although the “year of data” variable was found to have little impact on the size of the elasticities in our analysis). We also limited our review to studies using multiple equation models to estimate elasticities; simpler models are available but do not provide such robust estimates and are not consistent with the economic theory. We reviewed only studies that had an English abstract. Data were sparse for a few world regions, especially Australasia and South America, and few studies included information on the standard errors of the elasticity estimates, which prevented us from undertaking more sophisticated meta-analysis. We also had to aggregate foods into fairly broad groups to make the data comparable, and this is likely to have diluted some of the relations found. For example, sugary drinks were included within the sugar and sweets category, but sugary drinks typically show higher own price elasticities than other sugary foods, and consequently a stronger relation may have been found if sugary drinks had been examined separately, whereas the overall elasticity found for sweets may have been smaller. Finally, price elasticities assume that the relation between food prices and demand is linear, but this may not always be the case, particularly for large changes in price. Consequently, our estimates may underestimate the changes in demand that might occur in response to large increases in food prices, such as have been observed recently, particularly in developing countries.

Our elasticity estimates for food groups in high income countries are similar to those found in the United States,<sup>15</sup> and for meat are similar to those in a recent review of global meat prices.<sup>23</sup> Previous smaller studies have suggested that the relation between food prices and demand tends to be stronger in lower income countries and among lower income groups within countries, although none has quantified this in a systematic manner. None the less, this existing literature is consistent with our findings, adding weight to their validity.

### Conclusion

This study has synthesised the worldwide evidence base to investigate the impact of changing food prices on nutrition and

identified potential important negative impacts of food price rises especially among poor people in low income countries. Future work must also systematically evaluate the evidence on the price-demand relation between different foods, or between food and non-food items (cross price elasticities). A better understanding of these relations will help identify the foods that consumers select when their preferred foods can no longer be afforded (whether they reduce spending on all foods or switch to cheaper—healthier or less healthy—alternatives, etc). Further work is also required to understand how and why people choose the foods they eat in different contexts globally. The consequences for human health, as well as global economies, of major shifts in food consumption patterns resulting from changes in food prices are likely to be far reaching and will require much further investigation.<sup>25</sup>

**Contributors:** RG designed the study protocol, collected and entered the data, conducted the meta-regression analysis, and drafted and revised the paper. She is guarantor. LC revised the study protocol, collected and entered the data, and revised the draft paper. AD and RS initiated the project, assisted with study design, revised the study protocol, and revised the draft paper. RT entered the data and checked the data, and revised the draft paper. BS and MM assisted with study design and revised the draft paper. The corresponding author had full access to all the data in the study and had final responsibility for the decision to submit for publication.

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**Competing interests:** All authors have completed the ICMJE uniform disclosure form at [www.icmje.org/coi\\_disclosure.pdf](http://www.icmje.org/coi_disclosure.pdf) (available on request from the corresponding author) and declare: no support from any organization for the submitted work; no financial relationships with any organisations that might have an interest in the submitted work in the previous three years; no other relationships or activities that could appear to have influenced the submitted work.

**Ethical approval:** Not required.

**Data sharing:** Statistical code and datasets are available from the corresponding author at [rosemary.green@lshtm.ac.uk](mailto:rosemary.green@lshtm.ac.uk).

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**What is already known on this topic**

The relations between food prices and demand (own price elasticities) vary according to the type of food and income level of a country  
Worldwide food prices are volatile, and no systematic review has been done of global food price elasticities to determine how changes in food price will affect demand for food in countries with different income levels

**What this study adds**

Combined worldwide evidence shows that the impact of food price on demand for food is greatest in low income countries, and within countries among the poorest people

Rises in food prices are most likely to reduce demand for animal source foods such as meat, fish, and dairy, and will have less impact on demand for staple foods such as cereals

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## Tables

**Table 1 | Descriptive statistics for selected variables (n=3495 estimates)**

Categories for variables	No (%)
<b>Region:</b>	
Europe	1169 (33.4)
North America	379 (10.8)
South America	238 (6.8)
Asia	988 (28.3)
Africa	663 (19.0)
Australasia	58 (1.7)
<b>Country income*:</b>	
Low (GNI per capita of ≤\$1025)	1461 (41.8)
Middle (GNI per capita of \$1026-\$12 475)	858 (24.5)
High (GNI per capita of ≥\$12 476)	1176 (33.6)
<b>Study type:</b>	
Peer reviewed	1049 (30.0)
Grey literature	2446 (70.0)
<b>Data source:</b>	
Aggregate (national average statistics)	1931 (55.3)
Cross sectional (data from surveys)	1026 (29.4)
Panel (data from longitudinal surveys)	273 (7.8)
Scanner (home or supermarket scanner data)	265 (7.6)
<b>Food group†:</b>	
Fruit and vegetables	643 (19.1)
Meat	570 (16.9)
Fish	460 (13.7)
Dairy	435 (12.9)
Eggs	24 (0.7)
Cereals	455 (13.5)
Fats and oils	339 (10.1)
Sweets, confectionery, and sweetened beverages	82 (2.4)
Other	355 (10.6)

\$1.00 (£0.65; €0.76).

\*Gross National Income (GNI) data taken from World Bank database for 2011.

†n=3463, as not possible to classify 32 elasticity estimates into specified food groups.

**Table 2 | Mean percentage change (95% confidence interval) in food demand for 1% increase in food price by country wealth category, taken from predictions of meta-regression models\***

Food groups	Country wealth category		
	Low income(n=1412)	Middle income (n=827)	High income (n=1124)
Fruit and vegetables	-0.72 (-0.77 to -0.66)	-0.65 (-0.71 to -0.59)	-0.53 (-0.59 to -0.48)
Meat	-0.78 (-0.83 to -0.73)	-0.72 (-0.78 to -0.66)	-0.60 (-0.66 to -0.54)
Fish	-0.80 (-0.85 to -0.74)	-0.73 (-0.79 to -0.67)	-0.61 (-0.67 to -0.55)
Dairy	-0.78 (-0.84 to -0.73)	-0.72 (-0.78 to -0.66)	-0.60 (-0.66 to -0.54)
Eggs	-0.54 (-0.67 to -0.42)	-0.48 (-0.61 to -0.35)	-0.36 (-0.49 to -0.23)
Cereals	-0.61 (-0.66 to -0.56)	-0.55 (-0.61 to -0.49)	-0.43 (-0.48 to -0.36)
Fats and oils	-0.60 (-0.65 to -0.54)	-0.54 (-0.60 to -0.47)	-0.42 (-0.48 to -0.35)
Sweets, confectionery, and sweetened beverages	-0.74 (-0.82 to -0.65)	-0.68 (-0.77 to -0.59)	-0.56 (-0.65 to -0.48)
Other	-0.95 (-1.01 to -0.90)	-0.89 (-0.95 to -0.83)	-0.77 (-0.83 to -0.71)
All food groups combined	-0.74 (-0.79 to -0.69)	-0.68 (-0.73 to -0.62)	-0.56 (-0.61 to -0.50)

\*Predictions based on multiple regression model with random effects. Values of all covariates in the model are set to their mean for the purposes of predicting values, with the exception of year of data, which is set to 2008.

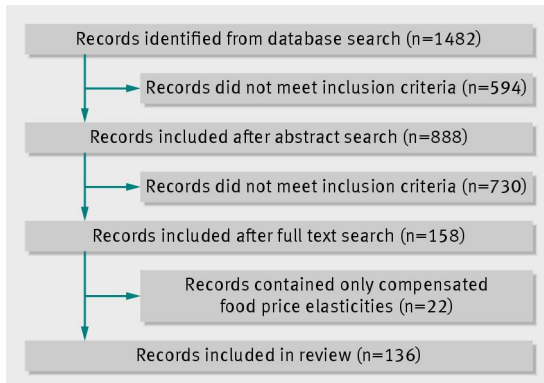
**Table 3| Mean percentage change (95% confidence interval) in food demand for 1% increase in food price by household wealth category, taken from predictions of meta-regression models**

Food group	Household wealth category	
	Lowest income (n=178)	Highest income (n=177)
Fruit and vegetables	-0.86 (-0.97 to -0.76)	-0.73 (-0.84 to -0.62)
Meat	-0.95 (-1.07 to -0.82)	-0.81 (-0.93 to -0.69)
Fish	-1.01 (-1.17 to -0.84)	-0.87 (-1.04 to -0.70)
Dairy	-0.92 (-1.08 to -0.78)	-0.79 (-0.93 to -0.64)
Eggs <sup>*</sup>	—	—
Cereals	-0.87 (-0.99 to -0.74)	-0.72 (-0.85 to -0.59)
Fats and oils <sup>*</sup>	—	—
Sweets, confectionery, and sweetened beverages	-0.87 (-1.06 to -0.70)	-0.73 (-0.91 to -0.55)
Other	-1.06 (-1.21 to -0.92)	-0.93 (-1.08 to -0.78)
All food groups combined	-0.91 (-1.00 to -0.83)	-0.77 (-0.86 to -0.68)

<sup>\*</sup>Insufficient data on which to base predictions.



## Figure



Flow diagram for selection of included studies