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Allcott H, Diamond R, Dubé JP, Handbury J, Rahkovsky I, Schnell M. Food Deserts and the Causes of Nutritional Inequality. *The Quarterly Journal of Economics*. 2019 Nov; 134(4):1793–1844.

What We Know, Think We Know, or Are Starting to Know

Nutrition is not a field that is short on controversial topics with hard opinions held on both sides of a given evidential divide. Typically, these controversial topics relate to foods or nutrients, i.e., saturated fat, sodium, red meat, or a specific type of diet, i.e., 'Carnivore' or vegan diets. Consequently, these are typically resolved by reference to evidence related to the dietary exposure in question.

But what of factors that influence diet and nutrition itself? Perhaps the most polarised topic in this regard is on the role of poverty and inequality in driving disparities in diet and health between the wealthier and poorer strata of society [1–3]. The reason for this polarisation is that the issue directly relates to socio-politico-economic ideologies, and so the evidence-base is filtered through such lenses, conflating what the evidence shows with the potential policy implications of that evidence [4].

However, for those producing the evidence, clarity is important in order that any policy be directed toward the most impactful interventions. "Food deserts" are one proposed characteristic of socio-economic disparities in diet and health that have been controversial [5,6]. The term "food desert" seems to have first appeared in formal policy documents of a British government taskforce in the mid-1990's and describes low-income communities where access to healthy, affordable foods is limited [5].

The concept is controversial because it lacks conceptual clarity and strong evidence that food deserts influence diets [5]. Further, access or availability does not necessarily determine dietary intake, particularly in low-income contexts where price, time, household composition, housing, food preparation skills, perishability, built environment, and a complex web of factors, influence diet [7,8].

Thus, "food desert" may in fact be a proxy for other factors influencing dietary intake in low-income strata of society. The latter point highlights a major issue of reductionism in the debate on the role of poverty in influencing diet and health, where the complexity is reduced to a single issue and then debated on that issue in isolation.

Clarity among complexity is always welcome. The present study investigated the relationship between diet and income using food purchase data and data on food retail outlet locations from the U.S.

The Study

The study used retail scanner data, which records all packaged goods purchased from any retail store, and sales data, from a nationally representative survey of U.S. households and retail stores. The survey data also included questionnaire responses in relation to socio-demographic factors, including education status, ethnicity, employment, nutrition knowledge, and health outcomes. The study data set further included a census of all food retailers in the U.S., including the month the store opened.

To characterise diet healthfulness, the study used the Healthy Eating Index [HEI], which is a diet quality index based on positive scores for healthy components [fruits, vegetables, wholegrains, dairy, plant and sea proteins], and negative scores for unhealthy components [refined grains, saturated fats, added sugars, sodium].

Several analyses were undertaken with these data. First, the relationship between healthy eating, healthy food availability, and income was analysed. Second, the relationship between either a supermarket opening in a locality, or a household moving to another locality, and respective changes in healthy eating was analysed.

Finally, the study modelled household demand for food items, and conducted "counterfactual" analysis modelling the associations with nutritional inequality if households in the bottom income strata were "exposed" to prices and availability experienced by the top income strata. Income was divided in quartiles [fourths].

Results: 61,000 unique households were included in the final analysis. The dataset included sales data for products sold at ~35,000 unique retail stores. Data on 6,721 entries of club stores, supercentres, and grocery stores [collectively termed "supermarkets"] was included. The included data spanned from 2004 to 2016.

Associations Between Household and Neighbourhood Income and Healthy Eating: Diet quality varied according to household income. Grams of added sugar per 1,000kcal decreased linearly as income increased, while share of bread purchases that were wholegrain breads, share of total calories that was "produce" [defined as fresh, canned, dried, and/or frozen fruits and vegetables], and composite healthy eating index score, increased linearly as income increased [see the **figure**, below, which illustrates these relationships].

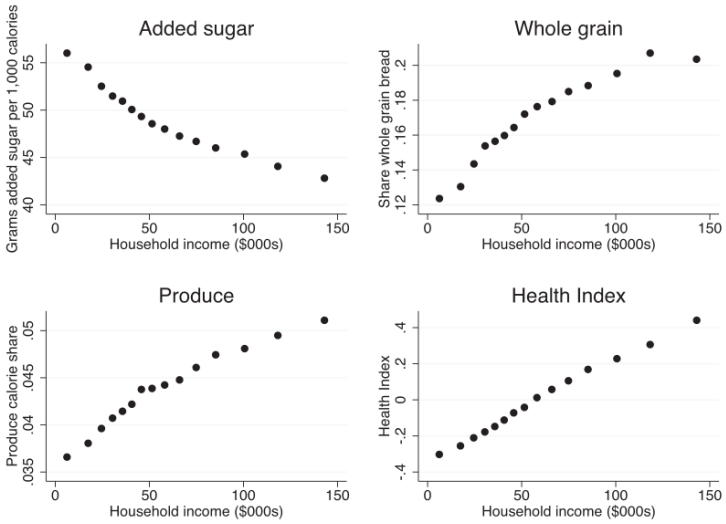


Figure *from paper illustrating the associations between* ***household income*** *and metrics of healthy eating: isolated nutrients [added sugars], foods [wholegrains and produce], and composite HEI score.*

Households in the top income quartile purchased groceries that were significantly higher in HEI scores than households in the lowest quartile.

The availability of healthy food components of the HEI also differed by neighbourhood income [based on the median income of a ZIP code area]. In this analysis, stores in higher income ZIP codes contained healthier options than stores in lower income ZIP codes [see **figure**, below].

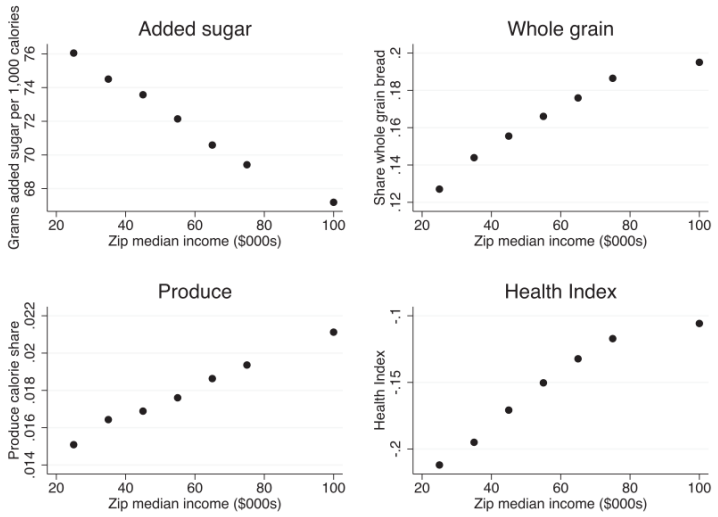


***Figure** from paper illustrating the associations between **ZIP code median income** and metrics of healthy eating: isolated nutrients [added sugars], foods [wholegrains and produce], and composite HEI score.*

Associations Between Supermarket Access and Healthy Eating: Based on median income of a ZIP code area, in low-income areas there were fewer supermarkets and more drug and convenience stores per capita [see **figure**, below].

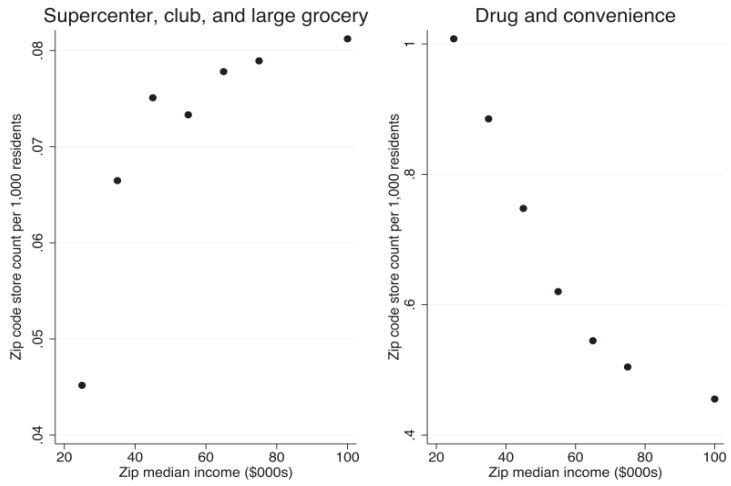


***Figure** from paper illustrating the associations between **ZIP code median income** and [**left**] supermarkets [defined as club stores, supercentres, and grocery stores] per 1,000 residents and [**right**] drug and convenience stores per 1,000 residents.*

The associations between a recent supermarket opening in the area and changes in grocery purchases showed no detectable increase in healthy food purchases. This finding was repeated when the analysis was confined to the ~23% of the sample living in food deserts [defined as a ZIP code with no supermarket].

The share of purchases spent in supermarkets was unchanged by a new supermarket opening in a ZIP code. Conversely, supermarket entry into a ZIP code had little effect on the spending share at drug and convenience stores. Thus, the effect of a new supermarket opening was to divert sales from other supermarkets to the new supermarket.

On average, 90% of shopping trips were made by car with an average distance of 5.2 miles, however, households in food deserts travelled an average of 7.0 miles. Thus, entry of a new supermarket had little effect on share of purchases in supermarkets as most households travel to shop in supermarkets. The differences in access to local supermarkets between high-income and low-income households explained only ~1.5% of the healthy eating differences observed between levels of income.

***Household Demand and Counterfactual Model of Healthy Eating*:** This analysis used correlations between purchase data and price to model "willingness to pay" [WTP] as an indicator of consumer demand, and a "counterfactual" analysis modelling equalising nutritional inequality between the highest and lowest income quartiles.

WTP for all healthy components of the HEI showed a strong and monotonic [i.e., never decreasing] increase as household incomes increased, with the exception of fish and plant proteins. High-income households showed less WTP for added sugars and sodium, while low-income households showed greater WTP for added sugar compared to high-income households. Higher income households also showed a preference for fresher foods with shorter shelf-lives.

Overall, the highest-income quartile exhibited the least price sensitivity and willingness to pay the most for healthy eating. Per 1,000kcal, the lowest-income quartile was willing to pay $0.43 compared to $1.14 among the highest-income quartile.

The counterfactual analysis sought to delineate between supply and demand factors to simulate changes in healthy eating that may occur under different conditions. This analysis suggested that 7-12% of the relationship between income and nutrition was explained by "supply", while 88-93% was explained by "demand" [more under ***Key Characteristic***, below]. Of this demand, 34% was explained by differences in education and nutrition knowledge [more under ***Interesting Finding***, below].

The Critical Breakdown

Pros: The study clearly detailed research questions being addressed, and the assumptions underpinning the analyses. The dataset used for the present analysis was enormous, and encompassed a nationally representative sample of household consumers and income levels, and a long duration of data over 12-years. The analysis distinguished between "supermarkets", defined as club stores, supercentres, and grocery stores, which carry a wider range of healthy food items at lower costs, and drug or convenience stores, which are generally associated with less healthy food options and often higher costs of healthy food items due to less economies of scale. The analysis adjusted for household size and ages, which influence both household income levels and spending on food.

Cons: The data on household purchases is confined to grocery purchases and does not include energy consumed away from the home [i.e., restaurants or fast-food outlets] or nonpackaged groceries. Thus, the analysis is not an assessment of total diets, and the differences in Healthy Eating Index food groups assessed reflect differences in take-home packaged groceries. While the dataset is voluminous, it is survey data rather than individual-level data, and the analyses are correlational. The data lacks more

thorough assessment of covariates, and only a limited number of potential mediators of the relationship between income and diet are included in the analysis of consumer demand. While food deserts feature prominently as a target of refutation, most of the analyses do not directly deal with the concept, or leave potentially important relationships unexamined [discussed further under ***Relevance***, below]. Perhaps the most important limitation of the present analysis is that as an economics analysis, it is based on very different assumptions that influence the analysis and interpretations of the findings [discussed further under ***Key Characteristic,*** below].

Key Characteristic

The key characteristic of the present study, and the one that requires most unpicking, is the fact that the analysis and assumptions reflect economic theory rather than prior knowledge derived from nutrition research. The supply and demand analysis defined supply as "availability and access", and demand as "preferences and characteristics". However, "preferences and characteristics" are based on assumptions derived from economic modelling, not assessment.

"Preferences" are defined by "utility", a reflection of the core rationalist assumption that underpins economic modelling, i.e., that consumers maximise their utility and welfare through the consumption of goods. This is contested because it fails to include other forces acting on choice, and therefore inferences made in relation to choice and demand in a real-life context are unrealistic [9,10]. In the context of the income-diet relationship, this assumption is tenuous because choice is constrained by factors beyond simply "preferences" [7,8].

"Characteristics" were defined as "observed" and "unobserved", with the observed characteristics of products stated in the paper as nutritional [e.g., added sugar, salt, saturated fat, etc.], and other [e.g., shelf-life, flavour, health implications]. This is included along with preferences in the model, with characteristics reflecting what additional money households would be willing to pay for a product due its characteristics. This assumes those characteristics are, in reality, why someone would choose one product over another, which is also an assumption fraught with some difficulty.

Taken together, these factors are deemed to constitute consumer demand. The model is essentially asking how, at a constant level of calories, would households redistribute their calorie demand from less healthy to more healthy products. And in the analysis, 88-93% of the difference in nutritional inequality according to income quartiles was explained by the demand factors.

This analysis also modelled the effects of the supply and demand factors on reducing nutritional inequalities using a counterfactual model, i.e., what would be the effect on nutritional inequalities if the lowest-income households were exposed to the prices [supply side], availability [supply side], product characteristics [demand side] and product preferences [demand side] or the highest-income households.

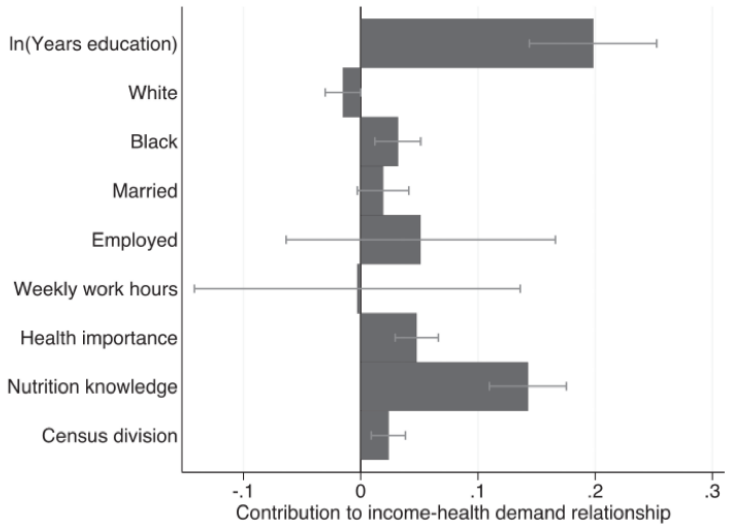
In this model, equalising prices and availability only reduced disparity in the HEI by ~9% between income groups. However, equalising product characteristics reduced the disparity by half, while further equalising for product preferences eliminated ~91% of the differences in HEI between highest-income and lowest-income quartiles.

In simple terms, the analysis suggested that if poor people exhibited the preferences and characteristics of wealthy people there would be no nutritional inequalities. We already know from the analysis that households in the highest-income quartile were willing to pay more for the healthy components of the HEI, and that highest-income households exhibited a preference for characteristics such as fresh produce. What factors could be driving differences in demand according to the model in this study?

Interesting Finding

Limitations of economic modelling and the guiding assumptions aside, the present study was very thorough in its analysis and explored factors that could explain why the demand analysis suggested that high-income households select for more healthy foods and low-income households select for less healthy foods.

The **figure** below illustrates the contributions of the variables included in this analysis. Education was the single largest explanatory variable, explaining 20% of the association between demand for healthy groceries and income, followed by nutritional knowledge at 14%. Other factors, such as being employed, health importance, and ethnicity, contributed to the overall differences between income and demand for healthy groceries.



This extended analysis places the findings in relation to "demand" in more context than the outputs of the initial economic model, because where factors like, e.g., education, exert such a strong contribution to the relationship between income and healthy grocery demands, it fundamentally alters the concept of "demand" away from the rationalist assumption of utilitarian choice. Demand is not independent of wider determinants.

Relevance

As you may have already gathered, *The Quarterly Journal of Economics* is not a habitual port of call for Deepdives. Nevertheless, economics has made some valuable contributions to our understanding of diet and health, particularly related to food insecurity [11–13]. The present study adds to this literature by providing a comprehensive set of analyses and insights using a vast nationally representative database of grocery purchases, supermarket locality, and household and neighbourhood income.

The study clearly demonstrates a gradient between income and diet quality that is linear, with households in the highest quartile of income purchasing groceries that are substantially higher in the HEI, and willing to pay more for the healthy components of the HEI. The constraint on spending was striking: $0.43/1,000kcal compared to $1.14/1,000kcal for low- and high-income groups, respectively.

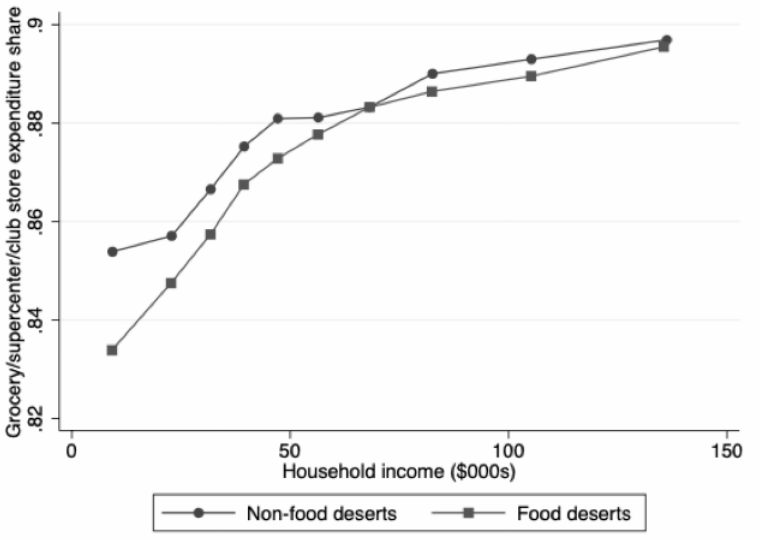
This finding is consistent with wider research demonstrating the limiting effect of low-income on diet quality [14,15]. Of particular note is that trends in dietary quality disparities are widening over time between high and low socio-economic strata [15].

The analysis also clearly demonstrated that low-income neighbourhoods have less supermarkets and more drug and convivence stores per 1,000 residents, and that stores in lower-income neighbourhoods offer less healthy groceries compared to higher-income neighbourhoods. One point to bear in mind is that the present study only focused on one specific aspect of food retail, and did not include fast-food outlets in a locality, and research suggests repeated exposure to fast-food retailers correlates with intake [we covered one such study in a previous Deepdive].

However, the entry of a new supermarket was not associated with changes in the healthfulness of grocery purchases. Wider research challenges the assumption that supermarkets displace local food retailers to the detriment of low-income communities, as the greater economy of scale often translates to lower food prices, reducing food insecurity in low-income neighbourhoods [11,16].

The study challenges the theory that "food deserts" limit access to healthy groceries. This is based on the evidence for a lack of effect of supermarket entry on healthy grocery purchases, which was also evident in neighbourhoods classified as "food deserts". The data suggests that this is due to consumer willingness to travel to shop at supermarkets, with individuals living in "food desert" neighbourhoods travelling farther [~7 miles] than the average distance [~5.2 miles].

However, it appears further analyses were left on the table. For example, while households in "food deserts" spent ~1% less of their grocery budgets in supermarkets compared to households not in "food deserts", this gap appeared to widen at the lowest deciles of income [illustrated in the **figure**, below]. These differences do not appear to have been explored further.



Nevertheless, despite the differences in the relationship between household income and healthy grocery purchases, and the less healthy groceries available in stores in low-income neighbourhoods, the counterfactual analysis suggests that these "supply-side" factors related to access/availability do not meaningfully explain differences in healthy grocery purchases.

Rather, "demand-side" factors explained almost all of the differences in this analysis. On first glance this would appear to suggest it boils down to a matter of choice, but the further analysis on variables related to demand falsifies this premise, as externalities such as education status, nutrition knowledge, health motivation, and ethnicity, all influence the income-demand associations. And this analysis contained a limited number of variables that we could expect to influence such a relationship [7,8].

This demonstrates why modelling based on assumptions related to preferences and characteristics, with preferences defined by rationalist utility and reduced to a modelling equation, are an unrealistic model of human behaviour in the real world [9].

Application to Practice

Are "food deserts" a barrier to a healthy diet? A criticism of the concept is that "food deserts" became a convenient catch-all phrase, and policy proposal solution to address, for a highly complex problem [17]. The present study builds on previous research by suggesting that "food deserts" may be too opaque a concept to capture income and neighbourhood disparities in healthy food access and diet quality [17,18].

The fact that externalities such as education status and nutrition knowledge [both are generally related] influence grocery purchasing is indicative of factors that underpin class-based disparities in diet quality and related health outcomes [14,15,19]. How to navigate such barriers given they may already be extant?

The present study does propose a solution: subsidies. If we assume that access is not necessarily the issue, other barriers may be more pertinent, income in particular. There is evidence, for example, that the modifications to the U.S. federal Supplemental Nutrition Assistance Program [SNAP] to incentivise fruit and vegetable consumption may increase purchasing of these foods [6].

The authors estimated that an annual means-tested subsidy to SNAP of $11-billion per year would be sufficient to raise the lowest-income quartile households to the same HEI level as the highest-quartile, a cost which is ~15% of the current SNAP budget of $71-billion.

This concludes the evidential discussion, please proceed to fight over the role of the government in population health...

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