Examining the Relationship between the Use of Supermarkets and Over-nutrition in Indonesia*

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AAEA Annual Meetings, July 27-29, 2014
Minneapolis, MN USA

Invited Paper Session:
"Transforming Food Markets - Implications for Nutrition and Livelihoods in Developing Countries"

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* The project was funded by the Australian Centre for International Agricultural Research (ACIAR). We are grateful to Professor Randy Stringer and Ms. Wahida in the Global Food Studies Program at the University of Adelaide, Australia for insight in the design of this study. We are also grateful for the assistance of current and former staff at the Indonesian Centre for Agricultural Socio Economic and Policy Studies (ICASPES) in survey development and design as well as data collection. The usual disclaimer applies.

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Abstract

This study examines the relationship between the use of modern food retailers and health outcomes, using data from a survey of 1180 urban households in Indonesia. The dependent variables include adult and child body-mass index (BMI) and the share of individuals overweight and obese. After controlling for individual and household characteristics and using standard and Lewbel instrumental variable approaches to control for unobservable characteristics, we do not find a statistically significant relationship between use of supermarkets and adult nutrition measures. On the other hand, there is mixed evidence for a negative effect of supermarkets on child nutrition, particularly for those in high-income households.

JEL classification: I15, P46, Q18

Key words: supermarket, diet, nutrition, BMI, Indonesia

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Food systems, both traditional and modern, are fundamentally connected to the health and welfare of society (Asfaw 2008; Hawkes 2008; Pingali 2007; Reardon and Timmer 2014; Timmer 2013). Thus, the food market transformation, or ‘supermarket revolution’ taking place in many countries across Asia impacts domestic and regional food systems (Faiguenbaum, Berdegue and Reardon 2002; Reardon et al. 2003). Drivers of changing food markets, including industrialization of agriculture, globalisation, foreign direct investment (FDI), urbanisation and increasing disposable incomes, may, to some extent, also be contributing to the diet and nutrition transition occurring among households in Asia (Mendez and Popkin 2004; Pingali 2007; Reardon and Timmer 2014).

There are related concerns that supermarket penetration in developing countries, including Indonesia, creates a food market environment that encourages ‘obesogenic’ diet transition, particularly increased consumption of energy-dense processed food at the expense of fresh fruits and vegetables and grains. Regardless, diet transition and the proliferation of more Western food consumption patterns throughout Asia and Indonesia are thought to be one cause of increases in non-communicable diet-related diseases such as obesity, cardiovascular disease and type II diabetes. (Matejowsky 2009; Mendez and Popkin 2004; Popkin 1999, 2006; Prentice 2006).

Diet-related health issues place additional burdens on economies already struggling with food security (Reardon and Timmer 2014). Recent epidemiological research suggests that children born into food insecure households, who then experience dramatic improvement in economic conditions during childhood, are more likely to have diet-related health issues (e.g. Type 2 diabetes, obesity) as adults (Prentice 2006). Furthermore, children who are obese are much more likely to experience a variety of health issues as adults (Thompson et al. 2004).

A set of studies has focused specifically on the relationship between modern food retail penetration and dietary transition in developing countries (Reardon and Berdegué 2002; Reardon et al. 2003; D'Haese and van Huylenbroeck 2005; Asfaw 2008; Tessier et al. 2008). However, the causal link between diet-related health outcomes and food market environments in developing countries is still not clear-cut, particularly for children in developing countries.

This paper addresses several gaps in the literature. Using a unique set of household-level data from a survey of urban Indonesia, we are able to test causal relationships between food market environment, namely the "supermarket effect", household food consumption patterns and diet related health outcomes for adults and children. While some previous studies suggest a link between diets, health and supermarkets, few have empirically tested the connection (Asfaw 2008; Tessier et al. 2008; Zhang, van der Lans and Dagevos 2012). Furthermore, this is the only study known to examine this relationship in Indonesia or to include both adults and children in the analysis.

Background – Supermarkets and Indonesia

Indonesia presents an interesting context in which to explore possible links between supermarket use and adverse diet-related health outcomes. First, the country is experiencing rapid economic growth, increasing household incomes, urbanisation, and food system transformation (World Bank 2007 and 2013; Reardon et al. 2014)

Second, previous research suggests that diets are transitioning (Reardon and Timmer 2014) and rates of obesity are increasing across all population groups and income strata (Roemling and Qaim 2012). Third, there has been substantial growth over the last two decades in the number of modern food retail outlets in Indonesia (Dyck, Woolverton and Rangkuti 2012; Suryadarma et al. 2010).

A study by Dyck, Woolverton and Rangkuti (2012) found that the number of supermarkets in Indonesia increased 67% from 1999 to 2009, but over the same period, the growth in the number of hypermarkets and mini-markets was much more profound. There were seven times more hypermarkets and 18 times more mini-markets selling food in Indonesian in 2009 compared to ten years prior. Some policymakers have expressed concerns that modern retailers will displace traditional food retail outlets in Indonesia. Yet, despite the growth in numbers, modern retail outlets accounted for only about 19% of food sales (Minot et al. 2013). As Suryadarma et al. (2010) outlines, modern retailers have attempted to compete with traditional retailers by offering competitive prices, providing access to a wide variety of food products (e.g. dairy, imported and frozen products), focusing on certain quality (e.g. organic, food safety) and convenience (e.g. packaged and ready-to-eat meals) attributes.

However, despite traditional retailers' decline in sales, modern retail penetration in Indonesia, there are still a large variety of "traditional" retail formats selling food products. These range from street vendors, peddlers (mobile vendors), warungs (small retail outlets), and wet markets. Suryadarma et al (2010) suggest that some traditional markets which focus on selling fresh food such as meat, chicken, fish, vegetables and fruits are able to compete against modern retailers.

Clearly Indonesia is experiencing supermarket expansion and diet transition, though the causal connection has not been established. Much of the research points to a potential negative impact of supermarket expansion in the form of unequal access to food and increased consumption of nutrient-poor, highly processed foods. However, there may be positive effects in terms of greater diet diversity and lower food prices (Hawkes 2008). Whether there is a "supermarket effect" resulting in diet-related health issues is the subject of the analyses presented in the following sections.

Data on Urban Indonesian Households

The analyses in the subsequent sections of this paper are based on data from a survey of 1180 urban households located in three cities across Java Island in Indonesia. The three cities, Surabaya, Bogor and Surakarta, represent large, medium and small cities, respectively. Households were selected using a stratified random sampling approach. We oversampled higher income areas and neighborhoods relatively closer to supermarkets to ensure households were likely to have access to modern retail outlets or supermarkets. Trained enumerators conducted interviews with the individual in the household responsible for most food purchase decisions.

The questionnaire collected socio-demographic information on each individual living in the household including gender, age, years of education completed, and the weight and height of each adult and child.[1] Information was also obtained on household religion, assets, income, food shopping behavior, and preferred outlet for purchasing different types of food. Respondents were also asked about their perceptions and use of seven main types of food retail outlets: hypermarkets, supermarkets, convenience stores, small shops (warung), semi-permanent stands, traditional wet markets, and peddlers. In this study, we use the term "supermarkets" to represent all types of modern food retailers in Indonesia, which include hypermarkets, supermarkets, and convenience stores (mini-markets).

A food expenditure module collected information used to calculate household expenditures for 67 food products. Specifically, for each product respondents indicated how often they purchased each product, their average expenditures and the main type of retail outlet used for purchasing each item. Respondents were also asked how consumption of each product had changed over the previous five years. The 67 food product categories and related questions were determined after numerous focus-group discussions and pre-testing of the questionnaire.

The descriptive statistics of relevant variables are provided in Table 1. In the empirical analyses, we analyze data from 3269 adults from 1060 households and 1398 children from 777 households.

[Insert table 1]

Supermarket Expenditure Shares

The explanatory variable of interest is '*supermarket*' which indicates the household's share of total annual food expenditures made in modern supermarkets. Recall that we define "supermarkets" to include the three types of modern food retail outlets, hypermarkets, supermarkets and mini-markets.

The expenditures for each food product category were calculated using information provided by respondents through their responses to three relevant questions. First, "*during the past month, how many times did your household purchase [particular food product X]*?" Second, "*for each purchase, what is the normal value (Rupiah) of [product X] bought for household consumption?*" Third, "*where do you buy most of the [product X]*?" Responses to these three questions are used to estimate the total annual amount spent on each food product category. As shown in Table 1, the unweighted average share of food purchased at modern outlets is 16%. However, taking into account the sampling weights and the amount spent by each household, about 19% of all food consumed by urban households was purchased at a modern outlet.

Measures of Diet-Related Health Status

The main indicator of health and nutrition used in this study is the Body Mass Index (BMI). BMIs are calculated using each individual's weight (kilograms) divided by height squared (meters^2). To normalize this indicator, we use BMI z-scores instead of crude BMI (Wang and Chen 2012). The z-scores for adults (individuals aged 19-65) are computed as demeaned individual BMI divided by group standard deviation, where the group means and standard deviations of BMI are calculated within each age-and-gender-specific cell.

The z-scores for children (individuals 2 to 18 years of age) are computed similarly, but we obtain group means and standard deviations directly from the United States

Center for Disease Control (US CDC) Growth Charts (2000). As suggested by the CDC, we exclude children under two years of age. By introducing BMI z-scores, we transform the dependent variable to a relative comparison between an individual BMI and a standardized benchmark, which simplifies interpretation of the results.

In addition to BMI z-scores, this study considers weight status, i.e. overweight and obese, adopting three definitions of each. First, the World Health Organization (WHO) defines overweight as a BMI above 25 and obese as above 30. Second, a WHO expert consultation (WHO, 2004) created alternative definitions for Indonesian urban adults in which overweight refers to a BMI above 22 and obese individuals are those with a BMI over 27. The third classification used is a relative measure, which applies for both adults and children. According to the US CDC, an individual is overweight if his/her BMI falls exceeds the 85th percentile within his/her age-gender-specific group. Similarly, if his/her BMI exceeds the 95th percentile, this individual is considered as obese.

In Table 1, we report crude BMI and relative weight status for each measure. As can be seen, average BMIs for adults and children are 22.6 and 18.2, respectively. According to the international WHO definition, the average adult BMI is well within the normal range. However, using the Indonesian-adjusted BMI cut-off value of 22 (WHO 2004), the mean BMI of adults in the sample (BMI = 22.6) is overweight. Given the controversies regarding both WHO standards, if we consider the relative measures we find that on average, 19% and 9% of the adults in this sample of Indonesian households are overweight and obese, respectively.

Methods for Estimating BMI, Overweight, and Obese

This section addresses our identification and estimation strategy and discusses the key variables used in the models. The main equation estimated is provided in equation (2):

$$Y_{ijk} = constant + \beta Supermarket_{jk} + \gamma' x_{ijk} + \theta' h_{jk} + \omega' m_k + u_{jik} \qquad (2)$$

Y_{ijk} is a measure of individual health status of adults and children and consists of a) a continuous proxy for BMI (kg/m^2) or b) binary indicators for overweight and obese, where i, j and k denote individual, household and city, respectively. As discussed in the previous section, the proxy for BMI is the BMI z-score for adults and children. For weight status, we consider all three measures of overweight and obese: 1) international WHO definition, 2) Indonesian-specific WHO definition, and 3) the CDC relative measures, for both adults and children, accordingly.

The explanatory variable of interest, $Supermarket_{jk}$, is the share of total household food expenditures made at modern food retail outlets (including hypermarkets, supermarkets and mini-markets) as described in Equation 1. When we consider individual health indicators, we expect that the coefficients on $Supermarket_{jk}$ will be significant and positive, indicating that a larger share of household food purchased at modern retailers is associated with a higher BMI among Indonesian adults and children living in urban areas. When we investigate weight status and use linear probability models (LPM), we also expect the coefficient to be positive.

However, the ordinary least squares estimate of the coefficient is likely to be biased and inconsistent due to correlation between the $Supermarket_{jk}$ variable and the error term. This may be caused by reverse causation, in which household health status affects their food shopping patterns. Alternatively, the correlation may be caused by an observed and/or unobserved variable which influence both shopping behavior and health status.

To mitigate this potential bias, we control for confounders that may influence BMI and health status in vectors x_{ijk}, h_{jk} and m_k. Vector m_k represents city-level time-invariant fixed effects and u_{ijk} is an i.i.d error term. Summary statistics for individual and household covariates included in vectors x_{ijk} and h_{jk}, respectively, are provided in Table 1 for both adults and children.

The vector x_{ijk} includes individual characteristics such as age, gender, and years of education for adults aged from 19 to 65. Individual-specific exogenous variables include age, age squared, gender (males = 1 and females = 0), and years of education completed. Nearly half of all individuals in the sample are males; the average adult age is 40 and the average child is around ten years of age. On average adults have completed 11 years of formal education. We do not control for education in the analyses of children, as most of children in this study had not yet completed their formal education.

Variables representing individual characteristics are included as they may impact food consumption decisions and diet-related health outcomes (Huston and Finke 2003; Schroeter, Anders, and Carlson 2013; Thompson et al. 2004). For example, more educated adults may have a higher awareness of the relationship between certain foods, nutrition and health outcomes, and thus make better food choices for themselves and their children (Turrell and Kavanagh 2006). More educated adults may also consider purchases of certain types of food perceived as "healthy", which may be relatively more expensive in Indonesia (e.g. fresh dairy and low fat meat products), to be an investment in their children's future (Huston and Finke 2003; Schroeter, Anders, and Carlson 2013).

Household characteristics are represented by the vector h_{jk}, which includes variables representing household income, religion, family size, number of refrigerators, and ownership of motorbikes, cars, and trucks. These variables are also thought to be associated with household food expenditures and lifestyle, which may in turn related to health status.

Six mutually-exclusive categories are used for monthly income: (i) less than 0.5 million Indonesian Rupiah (IDR), (ii) 0.5-1 million IDR, (iii) more than 1 million to 2 million IDR, (iv) more than 2 to 5 million IDR, (v) more than 5 to 10 million IDR, and (vi) more than 10 million IDR. As can be seen in Table 1, around 39% households earn less than 2 million IDR/month, 35% of households earn between 2 and 5 million IDR/month, and 26% earn more than 5 million IDR/month. As Smith, Bogin, and Bishai (2005) suggest, higher income households may have fewer economic barriers to purchasing certain types of more expensive food, and they may have a lower future discount rate, leading them to place a higher value on future health.

In addition to household income, religious customs and beliefs may also influence BMIs, thus we include a religion dummy (1 = Muslim household) in our econometric model. The majority (83%) of households included in the sample were Muslim.

The remaining covariates include family size as a crucial measure of 'quantity-quality trade-off',[2] the number of refrigerators (continuous), and ownership of motorbikes, cars and trucks (dummy), as proxies for household wealth and transport mobility.

Households own, on average, one refrigerator. Around 80% of households have at least one motorbike, car, or truck. In addition to being a measure of wealth, refrigerator ownership is likely to be related food purchase and consumption behavior as households with refrigerators are able to store perishable foods for longer periods of time. Similarly, ownership of a motor vehicle may influence both access to different types of food retailers and the physical activity of individuals in the household.

Finally, we include city level fixed effects (dummy variables) to avoid city-specific impacts on weight-related health due to level of urbanization or unobservable effects such as time-invariant geographical and climate conditions, social norms and cultural traditions.

Instrumental Variables Approach

After addressing a variety of confounders, it is likely that other unobservable factors are omitted that may impact both BMIs and shopping patterns. For example, personal preferences for processed convenience food may result in more frequent use of supermarkets and higher BMI. In this case, OLS would yield a positive coefficient on supermarket share even if the use of supermarkets has no causal effect on BMI. To address issues resulting from omitted variable bias and reverse causality, this study implements an instrumental variable (IV) approach.

Appropriate instruments should be strongly correlated with the endogenous variable $Supermarket_{jk}$, (the relevance condition) but uncorrelated with omitted variables that may affect dependent variables (exclusion restrictions). In practice, suitable instruments for food and nutrition analyses of cross-sectional data are not easy to find

(Subramanian and Deaton 1996; Park and Davis 2001; Abdulai and Aubert 2004). Previous studies of the relationship between modern retail outlet use, diet and health have used distance to nearest retail outlet as an instrument in other studies (e.g. Volpe, Okrent and Leibtag 2013). However, for Indonesia, distance is not a good measure of access to food retail outlets because in urban areas of Indonesia traffic congestion means that the time to travel short distances in motor vehicles is often substantial.

In this study, we use travel-time to the nearest supermarket as an instrument of the share of total household food expenditures made at modern food retailers. As Narayan et al. (2012) suggest, the actual cost of purchasing food at a specfic type of retail outlet is a function of not only the cost of the product, but also travel time to the outlet. We expect a negative relationship between the time it takes a household to reach the nearest supermarket and share of household food purchased at supermarkets.

In addition to the standard IV estimator, this study uses Lewbel's (2012) two-stage heteroskedasticity-based instrument. The motivation of using the Lewbel (2012) IV estimator is that inappropriate instruments may bias IV estimates thus producing results that are inferior to OLS estimates. Therefore, this article uses Lewbel (2012) approach as a safeguard. We rewrite equation (2) as follows:

$$Y_i = \alpha S_i + \delta' X_i + v_i \tag{3}$$

where Y_i is one of the original three diet-related health outcome variables, S_i denotes the potentially endogenous variable, *Supermarket*, X_i contains all control variables including individual, household and city characteristics, and v_i is a standard i.i.d error term.

Z_i is a vector of internal instruments that according to Lewbel (2012) can be either a subset of or identical to X_i. In our case, we select three exogenous variables for Z_i, namely, age, number of refrigerators, and household ownership of a motorbike, car, or truck.

Following Lewbel (2012) and recent examples in the literature such as Emran and Shilpi (2012), Volpe, Okrent, and Leibtag (2013) and Schroeter, Anders, and Carlson (2013), equation (4) is estimated:

$$S_i = \pi' Z_i + w_i \,. \tag{4}$$

The estimated error term from equation (4) is then used to generate high-order instruments $(Z_i - \bar{Z}_i)\widehat{w}_i$, where $\bar{Z}_i$ is the mean of Z_i and $\widehat{w}_i$is the residual from equation (4).

Lewbel (2012) demonstrates that α in equation (3) can be consistently estimated without exclusion restrictions when three conditions hold. First, $E(X_i{}'v_i) = 0$ and $E(Z_i' w_i)$ =0, which means all variables in X_i should be exogenous with respect to Y_i and all the variables in Z_i should be exogenous with respect to S_i. Second, $Cov(Z_i, v_i{}'w_i) =$ 0, which implies that Z_i is uncorrelated with the product of the two error terms in equations (3) and (4). Third, $Cov(Z_i, w_i{}^2) \neq 0$, which requires the existence of heteroskedasticity in equation (4). The last assumption can be formally examined by the Breusch-Pagan test.

Let $\tilde{Z}_i$ denote the high-moment instruments $(Z_i - \bar{Z}_i)\widehat{w}_i$. Equation (3) is then estimated in a conventional two-stage least squares (2SLS) manner with its first stage expressed as equation (5):

$$S_i = \eta' \tilde{Z}_i + \xi_i \; . \qquad (5)$$

In the next section, we report and discuss OLS, IV and Lewbel estimates. To check the robustness of these estimates, we show additional results from a combined estimation including the standard external IV and Lewbel (2012) high-order internal instruments. In other words, the newly constructed set of instruments, the IV+Lewbel, contains not only $(Z_i - \bar{Z}_i)\widehat{w}_i$ but also travel time to the nearest supermarket.

Empirical Results

The relationship between household food expenditure shares at supermarkets and diet-related health outcomes is empirically invested by examining results from estimations for adults and children.

Adult Measures of Over-nutrition

The coefficients from all four estimations (OLS, IV, Lewbel, and IV+Lewbel) of adult BMI z-scores are provided in Table 2. Overall, in all four models estimating adult BMI, we did not find a statistically significant relationship between share of food expenditures at supermarkets and adult BMI.

[Insert Table 2]

Columns (2) to (4) of Table 2 consider different methods for mitigating potential biases resulting from endogeneity. The first-stage coefficient in column (2) indicates a negative relationship between time to nearest supermarket and food expenditures shares at supermarkets, as expected, though the coefficient is only significant at the 10% level. Column (3) reports Lewbel estimates with high-moment internal instruments. The Breusch-Pagan χ^2 is sufficiently large to reject the null hypothesis of homoskedasticity of the error term (w_i) from equation (4), thus satisfying the third condition for the Lewbel approach. Also, the overidentification test based on the Hansen J statistic fails to reject the null hypothesis that all instruments are valid. Thus, we have some confidence in the overall set of instruments used the Lewbel estimation. Similar key indicators and results are reported in column (4) for the IV+Lewbel estimation.

Three covariates are significant in all four models: *Muslim, Family Size* and *Bogor*. Being in a Muslim family is associated with a significantly higher BMI among adults, other factors being equal. Larger families are associated with lower adult BMI, which is expected since a larger family for a given income means a lower per capita income. Adult residents of Bogor have significantly lower BMIs compared to those of Surabaya.

There is some evidence that adults in households with income above 5 million IDR/ month have higher BMIs, as expected given the fact that processed foods high in sugar and fat tend to be more expensive in Indonesia. The insignificant coefficients on the low-income variables suggest that adult BMIs do not change significantly as household income increases from low to middle income, however, increases from middle to high income are associated with increases in adult BMI.

The four estimations discussed above were repeated to examine relationships between overweight and obese households and supermarket share of food expenditures. Similar individual and household characteristics were considered and the results are summarized in Table 3. Columns (1) and (2) provide estimates using the international

WHO definitions of overweight and obese, columns (3) and (4) adopt Indonesian-specific standards, and columns (5) and (6) show results based on a relative measure.

[Insert table 3]

In general, there is no conclusive evidence of a statistically significant relationship between supermarket share of expenditures and the prevalence of overweight and obese adults in a household. Combining findings from tables 2 and 3, we conclude that when exogenous factors are controlled for and other confounding factors are addressed there is no solid evidence supporting the notion that an increase in the share of food expenditures at supermarkets is associated with higher adult BMIs or a higher probability of adults being overweight or obese.

Child Measures of Over-nutrition

The four equations estimated for adults were duplicated using data for children aged two to 18 as previously explained. The results of these estimations are provided in table 4.

[Insert table 4]

The share of food expenditures at supermarkets (*Supermarket*) is significant and positive in the OLS model of child BMI (column (1), table 4). However, more general causal evidence is not apparent from the IV, Lewbel and IV+Lewbel estimates provided in columns (2) to (4).

Looking at the significant coefficients of covariates, we see different results in table 4 for children relative to those for adults (table 2). The coefficient on the binary indicator, *Muslim,* is negative but weakly significant only in the OLS model, suggesting no relationship between religion and BMI z-score, in contrast to the positive coefficient for adults. Income effects for children BMIs also contrast those found for adults. Children from very-low-income households have significantly higher BMI z-scores compared to those from middle-income households.

The above two findings imply that at different growth stages, family background and socio-economic factors may affect individual BMIs differently and these effects could be non-linear along the time horizon. The non-linearity hypothesis, to be precise, an inverse U-shape effect of age, is supported by the coefficients on the variables *Age* and Age^2. The *Family size* coefficients in columns (1) to (4) of table 4 are all insignificant in contrast to those reported for adults. In other words, as family size increases, the BMI of adults tends to decline, but those of children are unaffected.

To explore possible differences in the "supermarket effect" across income groups, the analysis of the prevalence of overweight and obese children is carried out separately for each of three income groups. In table 5, columns (3) and (7) show that for high-income households, an increase in the supermarket share of food expenditures leads to an increased likelihood of a child being overweight and obese. This is true for the LPM, IV and IV+Lewbel estimation. We conclude that supermarket effects on body weight do exist among Indonesian children living in urban areas in high-income households.

[Insert table 5]

Conclusions and Implications

This study explores the relationship between increasing household food expenditure shares at modern food retail outlets on several measures of over-nutrition. This relationship is examined through estimation of the "supermarket effect" using ordinary least squares, standard instrumental variables approach, the Lewbel IV approach, and a combination of standard IV and Lewbel approaches in order to address possible biases resulting from endogeneity and controlling for other confounding factors related to individual, household, and location effects. This is the first study we are aware of that considers the impact of a "supermarket effect" on child health outcomes as well as adult.

For adults, we do not find conclusive evidence of a statistically significant relationship between increasing shares of food expenditures at supermarkets and higher individual BMI z-scores or increased rates of overweight and obese. For children, we do find some evidence to support a link between the use of supermarkets and the probability of a child being overweight or obese, but this is only true for high- income households. Child nutrition may be relatively unaffected by the use of supermarkets among lower- and middle-income households because they do not have the disposable income to purchase convenience food and other processed foods that are high in sugar and fat. Similarly, children in high-income households are relatively unaffected if the share of food purchased at supermarkets is low. But the combination of high income, and a large share of food purchased at supermarkets, seems to be sufficient to change diets and result in higher prevalence of overweight and obese children.

The results provide insight on the factors associated with dietary transition in Indonesia, and possible health implications of this change. This information may be useful for policymakers interested in programs to address diet-related diseases in developing countries such as Indonesia. For example, the results suggest that nutrition information messages to reduce the prevalence of over-nutrition should focus on children in higher income households that obtain a large share of their food from supermarkets and other modern food retailers.

Further work is needed to examine if the changing food markets have a positive or negative impact on diet quality, and ultimately the health status of individuals. The results of this study are based on this sample of urban Indonesian households, and the specific indicator of food marketing structure used to measure the impact of "supermarket effect". Future research could use alternate indicators of food market structure (e.g. exposure to fast-food outlets or expenditures on food-away-from home). Data on food consumption behavior for individuals was not available due to budget limitations, but additional studies may also consider using food recall or food diaries to measure the food consumption behavior of both adults and children in households, in order to obtain improved estimates of each individual's diet quality.

Footnotes

[1] Enumerators had previous training and experience collecting weight and height information from previous national studies, and we were able to use WHO methods and instruments to collect height and weight, which is important for BMI calculations.

[2] See the seminal work addressing intra-household resources allocation and inter-child quantity-quality trade-off by Rosenzweig and Wolpin (1980).

[3] It is also necessary to note that we do the same tests for adults by investigating sub-age groups, but we fail to find any significant results.

[4] Responses were not limited to increases or decreases, but rather four categories: 1) smaller quantities, 2) about the same, 3) larger quantities, and 4) never consume.

[5] The criteria for healthy foods are based on the "Dietary Guidelines for Americans 2010" issued by the US Department of Agriculture and used by Volpe, Okrent and Leibtag (2013).

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Table 1: Summary Statistics for Dependent (BMI z-scores, Overweight and Obese) and Explanatory Variables

Variables	Adult	Child
Supermarket (explanatory variable, 0 to 100)	15.9 (16.21)	16.56 (16.41)
BMI (dependent variable, continuous)	22.6 (4.22)	18.12 (4.46)
Overweight (dependent variable, 1 if overweight, 0 otherwise)	0.19 (0.39)	0.20 (0.40)
Obese (dependent variable, 1 if obese, 0 otherwise)	0.09 (0.28)	0.09 (0.28)
Time to the Nearest Supermarket (minutes, IV)	7.65 (4.94)	7.68 (4.92)
Age (years of age)	38.9 (12.72)	10.31 (4.91)
Male (1 if male, 0 otherwise)	0.46 (0.50)	0.50 (0.50)
Education (years of education completed, continuous)	11.14 (4.34)	N/A
Muslim (1 if Muslim, 0 otherwise)	0.82 (0.39)	0.83 (0.37)
Income (1 if in category, 0 otherwise)		
Less than 0.5 million IDR per month	0.04 (0.21)	0.04 (0.19)
0.5 to 1 million IDR per month	0.09 (0.29)	0.08 (0.28)
More than 1 to 2 million IDR per month	0.25 (0.44)	0.27 (0.45)
More than 2 to 5 million IDR per month	0.35 (0.48)	0.35 (0.48)
More than 5 to 10 million IDR per month	0.15 (0.36)	0.14 (0.34)
More than 10 million IDR per month	0.11 (0.31)	0.12 (0.32)
Family size (continuous)	4.44 (1.73)	4.99 (1.61)
Number of refrigerators (continuous)	0.83 (0.65)	0.83 (0.65)
Own motorbike, car or truck (1 if own, 0 otherwise)	0.81 (0.41)	0.80 (4.9)
Surabaya	1725 (53%)	699 (50%)
Bogor	777 (24%)	386 (28%)
Surakarta	767 (23%)	313 (22%)
Household (number of households in sample)	1060	777
Individuals (number of individuals in sample)	3269	1398

Notes: Means and standard deviations (in parentheses) are reported for each variable used in the analyses, except for city dummies, Surabaya, Bogor and Surakarta, where the total number of individuals is reported with the percent of individuals (in parentheses).

Table 2. Regression Results for Estimation of Adult BMI z-scores

Dependent Variable: BMI z-scores	**OLS (1)**	**IV (2)**	**Lewbel (3)**	**IV+Lewbel (4)**
Supermarket	-0.0010	0.0186	-0.0019	-0.0009
	(0.0014)	(0.0295)	(0.0051)	(0.0050)
Age	0.0010	-0.0085	0.0014	0.0009
	(0.0093)	(0.0176)	(0.0097)	(0.0097)
Age^2	-0.0000	0.0001	-0.0000	-0.0000
	(0.0001)	(0.0002)	(0.0001)	(0.0001)
Male	-0.0020	0.0337	-0.0037	-0.0020
	(0.0342)	(0.0641)	(0.0348)	(0.0348)
Education	0.0043	-0.0114	0.0051	0.0043
	(0.0049)	(0.0234)	(0.0062)	(0.0060)
Muslim	0.2548***	0.2913***	0.2531***	0.2549***
	(0.0522)	(0.0829)	(0.0534)	(0.0533)
Income (*reference 2-5 mil. IDR per month)*				
Below 0.5 mil. IDR per month	-0.0263	0.0218	-0.0286	-0.0263
	(0.1174)	(0.1374)	(0.1170)	(0.1168)
0.5-1 mil. IDR per month	0.0067	0.0928	0.0026	0.0068
	(0.0945)	(0.1649)	(0.0959)	(0.0959)
Above 1 to 2 mil. IDR per month	-0.0004	0.0835	-0.0044	-0.0003
	(0.0591)	(0.1429)	(0.0618)	(0.0617)
Above 5 to 10 mil. IDR per month	0.1540**	0.0445	0.1592**	0.1538**
	(0.0630)	(0.1794)	(0.0683)	(0.0683)
Above 10 mil. IDR per month	0.1332*	-0.0885	0.1438*	0.1329
	(0.0703)	(0.3453)	(0.0860)	(0.0852)
Family size	-0.0352***	-0.0383***	-0.0350***	-0.0352***
	(0.0114)	(0.0146)	(0.0113)	(0.0114)
Refrigerators	0.0747*	0.0431	0.0762*	0.0746*
	(0.0402)	(0.0649)	(0.0413)	(0.0413)
Own motorbike, car, or truck	0.0975	0.0182	0.1013	0.0974
	(0.0641)	(0.1428)	(0.0699)	(0.0703)
City (reference: lives in Surabaya)				
Bogor	-0.1347***	-0.1490**	-0.1340***	-0.1347***
	(0.0507)	(0.0594)	(0.0511)	(0.0510)
Surakarta	-0.0449	-0.0022	-0.0470	-0.0449
	(0.0496)	(0.0806)	(0.0503)	(0.0502)
Constant	-0.2203	-0.1113	-0.2255	-0.2202
	(0.2133)	(0.2786)	(0.2171)	(0.2171)
		first-stage		first-stage
minutes to the nearest supermarket		-0.1579*		-0.1781**
		(0.0881)		(0.0847)
F-stats [p-value]		3.21[0.07]	2.64 [0.00]	3.22 [0.02]
Hansen J statistic [p-value]			0.01 [0.92]	0.55[0.76]
Breusch-Pagan χ^2 [p-value]			213.16[0.00]	
R^2	0.02	0.05	0.02	0.02
Observations		3269		

Notes: ***, **, * indicate statistical significance at the 1%, 5% and 10% levels, respectively. Standard errors presented in parentheses are clustered at family level. All regressions control for individual and household characteristics and city fixed effects.

Table 3. Regression Estimates of Overweight and Obese Adults

	International cut-off		Indonesian cut-off		Relative measure	
	Overweight (1)	**Obese (2)**	**Overweight (3)**	**Obese (4)**	**Overweight (5)**	**Obese (6)**
			LPM			
Supermarket	0.0003	-0.0002	-0.0005	-0.0001	-0.0001	0.0004
	(0.0006)	(0.0003)	(0.0007)	(0.0005)	(0.0006)	(0.0004)
			IV			
Supermarket	0.0152	-0.0017	0.0072	0.0020	-0.0001	-0.0051
	(0.0143)	(0.0073)	(0.0137)	(0.0099)	(0.0107)	(0.0090)
			Lewbel			
Supermarket	0.0025	-0.0007	-0.0017	-0.0013	-0.0003	0.0002
	(0.0023)	(0.0010)	(0.0025)	(0.0016)	(0.0019)	(0.0014)
			IV+Lewbel			
Supermarket	0.0031	-0.0007	-0.0012	0.0011	-0.0003	0.0000
	(0.0024)	(0.0009)	(0.0024)	(0.0015)	(0.0018)	(0.0014)
Individual attributes	YES	YES	YES	YES	YES	YES
HH attributes	YES	YES	YES	YES	YES	YES
City dummies	YES	YES	YES	YES	YES	YES
Observations	3269	3269	3269	3269	3269	3269
if binary=1	788	156	1677	434	616	282
	(24.1%)	(4.8%)	(51.3%)	(13.3%)	(18.9%)	(8.6%)

Notes: ***, **, * indicate statistical significance at the 1%, 5% and 10% levels, respectively. Standard errors presented in parentheses are clustered at family level. All regressions control for individual and household characteristics and city fixed effects.

Table 4. Regression Results for Estimation of Child BMI z-scores

Dependent Variable: BMI z-scores	OLS (1)	IV (2)	Lewbel (3)	IV+Lewbel (4)
Supermarket	0.0080**	0.0457	0.0118	0.0129
	(0.0039)	(0.0535)	(0.0094)	(0.0093)
Age	0.0960*	0.1627	0.1027**	0.1046**
	(0.0492)	(0.1105)	(0.0509)	(0.0509)
Age^2	-0.0079***	-0.0101**	-0.0081***	-0.0082***
	(0.0022)	(0.0040)	(0.0022)	(0.0022)
Male	0.0841	0.0874	0.0844	0.0845
	(0.0940)	(0.0962)	(0.0934)	(0.0934)
Muslim	-0.2260*	-0.1088	-0.2142	-0.2109
	(0.1313)	(0.2286)	(0.1346)	(0.1351)
Income (*reference 2-5 mil. Rp per month*				
Below 0.5 mil. Rp per month	0.8000***	1.0970**	0.8300***	0.8384***
	(0.2524)	(0.4850)	(0.2571)	(0.2568)
0.5-1 mil. Rp per month	0.0363	0.2969	0.0626	0.0700
	(0.2381)	(0.4345)	(0.2417)	(0.2411)
Above 1 to 2 mil. Rp per month	0.0762	0.3002	0.0988	0.1052
	(0.1454)	(0.3533)	(0.1548)	(0.1546)
Above 5 to 10 mil. Rp per month	0.2034	-0.0913	0.1737	0.1654
	(0.1721)	(0.4429)	(0.1820)	(0.1808)
Above 10 mil. Rp per month	0.2383	-0.3083	0.1832	0.1678
	(0.2006)	(0.7996)	(0.2340)	(0.2322)
Family size	0.0180	0.0448	0.0207	0.0214
	(0.0339)	(0.0536)	(0.0342)	(0.0342)
Refrigerators	0.2260**	0.0952	0.2128*	0.2091*
	(0.1064)	(0.2212)	(0.1102)	(0.1102)
Own motorbike, car, or truck	0.0364	-0.1170	0.0209	0.0166
	(0.1544)	(0.2815)	(0.1577)	(0.1581)
City (reference: lives in Surabaya)				
Bogor	0.0116	0.0222	0.0126	0.0129
	(0.1238)	(0.1301)	(0.1231)	(0.1230)
Surakarta	0.0681	0.1613	0.0775	0.0801
	(0.1328)	(0.1926)	(0.1336)	(0.1335)
Constant	-0.7001*	-1.7393	-0.8048*	-0.8342*
	(0.3789)	(1.5453)	(0.4492)	(0.4484)
		first-stage		first-stage
minutes to the nearest supermarket		-0.1981*		-0.2368**
		(0.1066)		(0.1027)
F-stats [p-value]		3.46[0.06]	17.58[0.00]	16.46 [0.00]
Hansen J statistic [p-value]			1.53[0.22]	1.95[0.38]
Breusch-Pagan χ^2 [p-value]			131.09 [0.00]	
R^2	0.08	0.01	0.08	0.08
Observations			1398	

Notes: ***, **, * indicate statistical significance at the 1%, 5% and 10% levels, respectively. Standard errors presented in parentheses are clustered at family level. All regressions control for individual and household characteristics and city fixed effects.

Table 5. Estimation of Overweight and Obese Children by Household Income Groups

Outcome:	Overweight				Obese			
Income group:	Low (1)	Middle (2)	High (3)	All (4)	Low (5)	Middle (6)	High (7)	All (8)
				LPM				
Supermarket	-0.0001	-0.0002	0.0034**	0.0015	-0.0003	-0.0011	0.0019	0.0004
	(0.0018)	(0.0016)	(0.0015)	(0.0010)	(0.0010)	(0.0011)	(0.0013)	(0.0007)
				IV				
Supermarket	0.0078	-0.0097	0.0046	-0.0019	0.0118	-0.0138	0.0020	0.0008
	(0.0222)	(0.0156)	(0.0246)	(0.0117)	(0.0142)	(0.0124)	(0.0170)	(0.0074)
				Lewbel				
Supermarket	-0.0001	0.0014	0.0055***	0.0030	0.0005	0.0002	0.0038**	0.0002
	(0.0049)	(0.0020)	(0.0020)	(0.0020)	(0.0021)	(0.0014)	(0.0018)	(0.0014)
				IV+Lewbel				
Supermarket	0.0003	0.0013	0.0055***	0.0028	0.0011	-0.0002	0.0038**	0.0002
	(0.0050)	(0.0020)	(0.0020)	(0.0019)	(0.0024)	(0.0014)	(0.0018)	(0.0014)
Individual attributes	YES	YES	YES	YES	YES	YES	YES	YES
Parental attributes	YES	YES	YES	YES	YES	YES	YES	YES
HH attributes	YES	YES	YES	YES	YES	YES	YES	YES
City dummies	YES	YES	YES	YES	YES	YES	YES	YES
Observations	543	467	388	1398	543	467	388	1398

Notes: ***, **, * indicate statistical significance at the 1%, 5% and 10% levels, respectively. Standard errors presented in parentheses are clustered at family level. All regressions control for individual, parental and household characteristics and city fixed effects.