Original article

Trade openness and the obesity epidemic: a cross-national study of 175 countries during 1975–2016

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A R T I C L E   I N F O

A B S T R A C T

Purpose: This study assessed the longitudinal relationship between trade openness and obesity rate across 175 countries during 1975–2016.
Methods: Two-way (country and year) fixed-effects regressions were performed to examine the openness index (i.e., sum of export and import over gross domestic product) in relation to country obesity rate, using data from World Health Organization and World Bank.
Results: The openness index was found to be positively associated with country obesity prevalence—a 10% increase in the openness index was associated with an increase in obesity rate by 0.80% (95% confidence interval, 0.67%–0.94%). Across continents, the positive relationship between the openness index and obesity prevalence was strongest among Asian countries, followed by countries in North America and Africa. Across income levels, the positive relationship between the openness index and obesity prevalence was strongest among lower middle-income countries, followed by upper middle-income countries and low-income countries. In contrast, no relationship between the two was identified among high-income countries.
Conclusions: Trade openness was positively associated with country obesity prevalence, and its influence concentrated among developing nations. Policy makers should closely monitor the evolution in obesity rate during trade liberalization and nutrition transition to minimize its negative impact on weight-related population health.

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Introduction

In only three decades, obesity evolved from a minor issue, which concerned only a few endocrinologists, to a leading cause of morbidity and premature mortality worldwide [1–3]. Obesity is associated with an elevated risk of various chronic diseases, such as type II diabetes, hypertension, dyslipidemia, coronary heart disease, and certain types of cancer, and consumes substantial social resources [4–9]. Global obesity rate among men and women had increased from 3.2% to 6.4% in 1975 to 10.8% to 14.9% in 2014, respectively [10]. It was projected that by 2025, global obesity prevalence would reach 18% in men and exceed 21% in women, and severe obesity would exceed 6% in men and 9% in women [10].

Economic globalization, partially characterized by trade liberalization and openness, is associated with reduced poverty and improved population health outcomes [11–15]. On the other hand, economic theory and empirical evidence also indicate the possibility of the introduction of negative health externalities to a local economy via trade openness [16–18]. Previous research on the health impact of globalization reveals several pathways that may link trade openness to an elevated obesity rate in a traditionally closed economy, independent of economic growth. First, a "supermarket revolution," characterized by the rapid rise of supermarkets

in the developing regions, started in the early 1990s among Latin American countries and further spread to Asian countries in 2000s. This revolution pertaining to food retailers has profoundly transformed the agri-food markets in those regions by replacing small farms and processing or distribution firms, increasing food availability, and reducing price [19—21]. Second, the integration of the domestic and international market bridges modern food industries and foodservice distributors (e.g., fast food restaurants and convenience stores) to local residents [22]. Third, globalization through free trade and investment agreements (e.g., World Trade Organization or General Agreement on Tariffs and Trade) has resulted in a substantial rise in calorie availability, especially from high-sugar/fat energy-dense foods [23]. Fourth, trade openness has been closely associated with advances in technology and motorized transportation, which discourages household-, work-, and travel-related physical activities while increasing sedentary time [24,25]. Finally, from a socialization perspective, economic openness may enhance local residents' familiarity with and acceptance of a Western diet [26—28], which consequently influences their own weight management and obesogenic behaviors [29—31].

Trade liberalization and trade openness are closely related but not identical. Trade liberalization includes policy measures to increase trade openness (e.g., lower tariff rate and join free trade agreements between countries), whereas increased trade openness typically refers to an expansion in the size of an economy's tradable sectors relative to total output. Increased trade openness can be but is not necessarily the result of trade liberalization [32]. Literature that explores trade liberalization/openness in relation to obesity has accumulated over the past two decades. Food has been a much traded commodity for millennia, but the current rapid growth of the international food market is unparalleled and fueled by new marketing techniques and modern supply chains [33]. This growth is marked by profound changes in the type, quantity, cost, and desirability of foods available for consumption, which is a result of the globalized agri-food systems and drives nutrition transitions toward a Western diet [34]. There is an established conceptual framework linking trade liberalization/openness to health outcomes, which points to a resultant increase in the availability of highly processed, energy-dense, nutrient-poor foods among developing countries [35]. An assessment of the impact of trade liberalization between the United States and Mexico on obesity following the signing of the North American Free Trade Agreement found that Mexico imports more corn, soybeans, sugar, snack foods, and meat products from the United States [36]. As well, the Mexican food system increasingly resembles the industrialized U.S. food system as a consequence of the intensified U.S. agribusiness investment in Mexico's food supply chain from production and processing to distribution and retail [36]. Neuman et al. [37] conducted a cross-sectional study that assessed national income and trade openness in association with body weight status among populations in 38 developing countries. A recently developed theoretical trade model suggests international trade and other globalization factors produce a negative health externality (i.e., obesity) in the importing country [38]. Research based on this model evaluated the influence of trade openness and overweight/obesity prevalence across the 26 Brazilian states plus the Federal District during 1988—2008 [39].

Building on previous research, this study aimed to examine the relationship between trade openness and the global obesity epidemic. We hypothesized that trade openness would be positively correlated with country obesity rate. The study contributes to the relevant literature from the following aspects. First, the study period spans the past 42 years during which the obesity epidemic rose and spread worldwide, providing a longitudinal design that tracked the trajectory of trade openness and the obesity epidemic over time. Second, the study covered 175 countries worldwide, which enabled a large number of subgroup analyses to reveal the potential heterogeneous influences of trade openness on obesity across geographical regions, income levels, and stages of economic growth. Finally, the study adopted a two-way fixed effects identification approach (i.e., country and year fixed effects), which eliminates potential confounding bias from time-invariant country-specific differences as well as the global trends in trade openness and obesity prevalence.

Methods

Data

Data on annual country-specific age- and sex-standardized adult obesity prevalence from 1975 to 2016 were retrieved from the Global Health Observatory of the World Health Organization (WHO) [40]. Data on annual country-specific openness index, gross domestic product (GDP) per capita, total population, and percentage of rural over total population from 1975 to 2016 were retrieved from the World Development Indicators of the World Bank (WB) [41]. The openness index is defined as the sum of export and import over GDP. GDP across years and countries was converted to constant 2016 $US.

A total of 175 countries had relevant data and thus were included in the statistical analyses, but the data are unbalanced as missing variable values are present for certain countries and years. Across a total of 7350 country years, 6366 or approximately 87% of the observations with complete values for all variables of interest (i.e., adult obesity prevalence, the openness index, GDP per capita, total population, and percentage of rural over total population) were included in the statistical analyses.

Statistical analyses

Country fixed effects regressions were performed to estimate the longitudinal relationship between trade openness and adult obesity during 1975—2016. Country fixed effects regressions exclusively used within-country variations in the degree of trade openness across the 42-year study period to examine its impact on the evolution of the obesity epidemic and therefore eliminated potential confounding bias resulted from time-invariant between-country differences in characteristics, such as geographical location or political regime. The dependent variable is log-transformed adult obesity prevalence. The primary independent variable is log-transformed openness index. Adjusted covariates include log-transformed GDP per capita, total population, and percentage of rural over total population, and year fixed effects (a total of 41 categorical variables for each year from 1976 to 2016, with the year 1975 as the reference group). The year fixed effects controlled for the global temporal trends of the obesity epidemic that were shared across countries.

Country fixed effects regressions were performed on the overall sample of 175 countries, and subsamples stratified by continent (i.e., Africa, Asia, Europe, Oceania, North America, and South America), income level (i.e., low-income, lower middle-income, upper middle-income, and high-income countries), and Organization for Economic Co-operation and Development (OECD) membership status (i.e., OECD countries and nonOECD countries). Countries' income level and OECD membership status were based on the 2016 WB classifications.

Regression coefficient interpretation

We took natural logarithm for both the dependent variable and the independent variables in the country fixed effects regressions.

Therefore, a regression coefficient can be interpreted as the percentage change of the dependent variable in response to a unit percentage change of the independent variable. More specifically, an estimated coefficient of β denotes that a 10% increase in the independent variable (e.g., the openness index) is associated with a change of the dependent variable (i.e., adult obesity prevalence) by $(1.10^{\beta}-1) \times 100\%$.

Sensitivity analyses

A set of sensitivity analyses was conducted to assess the robustness of findings across model and covariate specifications. In particular, we added the natural logarithms of the following county- and year-specific variables into the regressions: demeaned GDP per capita squared (to prevent multicollinearity with GDP per capita), life expectancy (retrieved from the WHO Global Health Observatory) [40], under-five mortality rate (retrieved from the United Nations Inter-agency Group for Child Mortality Estimation) [42], and years of schooling (retrieved from the Barro-Lee Educational Attainment Dataset) [43]. Because of the substantial missing values (22%) in life expectancy, mortality rate, and years of schooling, merely 137 of the 175 countries were retained in the analyses.

Results

Figure 1 shows the time trends of the openness index and global obesity rate from 1975 to 2016. The global average adult obesity prevalence steadily increased from 5% in 1975 to 19% in 2016, with a 42-year average of 12%. The openness index steadily increased from 63% in 1975 to 92% in 2008, underwent a moderate decline afterward but reached 93% in 2012, and then gradually decreased to 85% in 2016, with a 42-year average of 80%.

Figure 2 shows the relationship between the openness index and obesity rate during 1975–2016 in a scatterplot. To facilitate visualization, a line was fitted using a nonparametric locally weighted regression. A positive association between the openness index and obesity rate was observed.

Table 1 reports modeling results from the country fixed effects regression. The log-transformed openness index was found to be positively associated with the log-transformed adult obesity prevalence. A 10% increase in the openness index was associated with an increase in adult obesity prevalence by 0.80% (95% confidence interval, 0.67%–0.94%). In addition, the log-transformed GDP per capita, percentage of rural over total population, and total
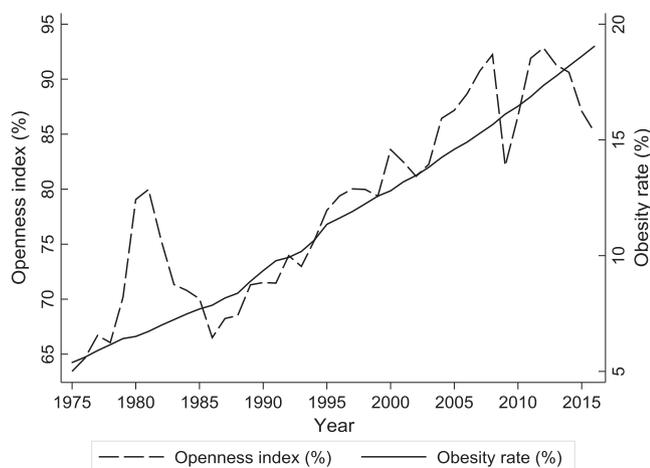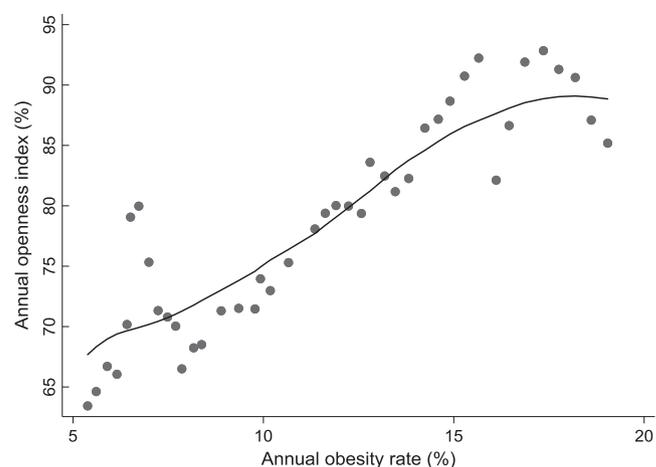

Fig. 2. Relationship between the openness index and obesity rate, 1975–2016. *Notes:* The line was fitted using a nonparametric locally weighted regression.

population were found to be positively associated with log-transformed adult obesity prevalence. A monotonically increasing temporal trend of the global adult obesity prevalence was indicated by the estimated coefficients of the year fixed effects.

Table 2 reports the modeling results from subgroup analyses. Across continents, the positive relationship between the openness index and adult obesity prevalence was strongest among countries in Asia—a 10% increase in the openness index was associated with an increase in adult obesity prevalence by 1.44%. A similar but less strong relationship was identified among countries in North America and Africa—a 10% increase in the openness index was associated with an increase in adult obesity prevalence by 0.41% and 0.21%, respectively. In contrast, no relationship between the openness index and adult obesity prevalence was identified among countries in Europe and Oceania. Moreover, a negative relationship between the openness index and adult obesity prevalence was identified among countries in South America—a 10% increase in the openness index was associated with a decrease in adult obesity prevalence by 0.51%. Across income levels, the positive relationship between the openness index and adult obesity prevalence was strongest among lower middle-income countries, followed by upper middle-income countries and low-income countries—a 10% increase in the openness index was associated with an increase in adult obesity prevalence by 0.88%, 0.57%, and 0.42% among lower middle-income, upper middle-income, and low-income countries, respectively. In contrast, no relationship between the openness index and adult obesity prevalence was identified among high-income countries. Adult obesity prevalence in relation to the openness index were identified among both OECD and non-OECD countries, although the effect tended to be larger among the latter—a 10% increase in the openness index was associated with an increase in adult obesity prevalence by 1.03% among non-OECD countries and 0.44% among OECD countries.

Regression estimates from the sensitivity analyses based on the 137 countries were fairly comparable to those based on the main analyses using the full sample of 175 countries. A 10% increase in the openness index was associated with an increase in adult obesity prevalence by 0.76% (95% confidence interval, 0.63%–0.90%). In addition, a 10% increase in the openness index was associated with an increase in adult obesity prevalence by 0.82% ($P < .001$), 0.75% ($P < .001$), and 0.11% ($P > .05$) among lower middle-income, upper middle-income, and low-income countries, respectively. Finally, a 10% increase in the openness index was associated with an increase in adult obesity prevalence by 0.93% ($P < .001$) among non-OECD countries and 0.10% ($P > .05$) among OECD countries.

Fig. 1. Time trends of the openness index and global obesity rate, 1975–2016.

Table 1
Results from country fixed effects regression

Independent variable	Natural logarithm of adult obesity prevalence, coefficient (95% CI)
Natural logarithm of openness index	0.084[†] (0.070, 0.098)
Natural logarithm of GDP per capita	0.046[†] (0.035, 0.057)
Natural logarithm of percentage of rural over total population	0.110[†] (0.078, 0.142)
Natural logarithm of total population	0.651[†] (0.620, 0.682)
Year fixed effects	
1975	Reference
1976	0.041[*] (0.002, 0.080)
1977	0.070[†] (0.031, 0.110)
1978	0.096[†] (0.057, 0.135)
1979	0.120[†] (0.081, 0.159)
1980	0.136[†] (0.098, 0.175)
1981	0.167[†] (0.128, 0.206)
1982	0.210[†] (0.171, 0.249)
1983	0.243[†] (0.204, 0.282)
1984	0.276[†] (0.237, 0.315)
1985	0.309[†] (0.270, 0.348)
1986	0.339[†] (0.300, 0.378)
1987	0.364[†] (0.324, 0.404)
1988	0.390[†] (0.350, 0.430)
1989	0.421[†] (0.381, 0.461)
1990	0.458[†] (0.418, 0.498)
1991	0.490[†] (0.450, 0.529)
1992	0.514[†] (0.474, 0.554)
1993	0.541[†] (0.501, 0.582)
1994	0.570[†] (0.530, 0.610)
1995	0.594[†] (0.553, 0.635)
1996	0.619[†] (0.578, 0.660)
1997	0.644[†] (0.603, 0.686)
1998	0.673[†] (0.631, 0.714)
1999	0.699[†] (0.657, 0.740)
2000	0.715[†] (0.673, 0.757)
2001	0.743[†] (0.701, 0.785)
2002	0.765[†] (0.722, 0.807)
2003	0.783[†] (0.740, 0.827)
2004	0.798[†] (0.754, 0.842)
2005	0.813[†] (0.768, 0.858)
2006	0.830[†] (0.784, 0.876)
2007	0.846[†] (0.799, 0.893)
2008	0.863[†] (0.815, 0.912)
2009	0.898[†] (0.850, 0.946)
2010	0.913[†] (0.865, 0.962)
2011	0.926[†] (0.876, 0.976)
2012	0.943[†] (0.893, 0.994)
2013	0.964[†] (0.913, 1.015)
2014	0.986[†] (0.934, 1.037)
2015	1.021[†] (0.970, 1.072)
2016	1.047[†] (0.995, 1.098)

[*] .01 ≤ P < .05.
[†] P < .001.

Discussion

This study assessed the longitudinal relationship between trade openness and obesity prevalence across 175 countries over the past 42 years from 1975 to 2016, using WB and WHO country-level data. The openness index, defined as the sum of export and import over GDP, was found to be positively associated with country adult obesity prevalence. In addition, the influence of trade openness on obesity tended to concentrate among developing countries and countries that traditionally adopted a non-Western diet. These findings were in line with Miljkovic et al.'s theoretical trade model in which international trade introduces a larger negative health externality, namely obesity, to an importing country that is more "predisposed to it by a given set of living and/or working conditions."[38]

This study confirmed some but not all findings documented in previous research. Vogli et al. [44] found economic globalization to

Table 2
Results from subgroup regression analyses

Dependent variable: natural logarithm of adult obesity prevalence	Independent variable: natural logarithm of openness index, coefficient (95% CI)
All (country = 175)	0.084[*] (0.070, 0.098)
Africa (country = 48)	0.022[†] (0.003, 0.042)
Asia (country = 41)	0.150[*] (0.124, 0.176)
Europe (country = 41)	−0.006 (−0.026, 0.015)
Oceania (country = 10)	−0.032 (−0.070, 0.006)
North America (country = 23)	0.043[*] (0.021, 0.067)
South America (country = 12)	−0.054[*] (−0.084, −0.024)
Low-income economies (country = 26)	0.044[*] (0.025, 0.062)
Lower middle-income economies (country = 48)	0.092[*] (0.071, 0.113)
Upper middle-income economies (country = 50)	0.060[*] (0.038, 0.081)
High-income economies (country = 51)	−0.026 (−0.054, 0.002)
Non-OECD countries (country = 139)	0.107[*] (0.092, 0.122)
OECD countries (country = 36)	0.046[‡] (0.019, 0.071)

Country categorizations by income level and OECD membership status were based on the World Bank 2016 classifications. Country fixed effects regressions were performed, controlling for the natural logarithm of openness index, natural logarithm of GDP per capita, natural logarithm of percentage of rural over total population, natural logarithm of total population, and year fixed effects (1975–2016).
[*] P < .001.
[†] .01 ≤ P < .05.
[‡] .001 ≤ P < .01.

be positively associated with mean body mass index (BMI) across 127 countries. Goryakin et al. [45] examined the impact of economic globalization on overweight/obesity among 56 low- and middle-income countries. A composite globalization index was found to be associated with individuals' overweight/obesity risk [45]. Neuman et al. [37] reported that foreign direct investment was positively associated with BMI, whereas the tariff rate was negatively associated with BMI among poor and rural residents in low- and middle-income countries. Similarly, we found the strongest positive association between trade openness and obesity prevalence was among lower-middle income countries, whereas no association was identified in high-income countries. One study indicated that trade liberalization in Central American countries over the past two decades contributed to the rising obesity rate through facilitating the nutrition transition toward a Western diet [46]. In contrast, a more recent investigation examining different types of globalization in relation to diet and obesity across 15–23 countries suggests that social globalization, instead of economic or political globalization, is a robust predictor for elevated obesity rate and increased energy/fat intake [47]. Perhaps surprisingly, this study identified a negative relationship between trade openness and adult obesity risk among countries in South America. This finding appears to contradict Miljkovic et al. [39], which documented an increase in overweight/obesity rate in response to trade liberalization across states in Brazil. It is possible that the rise in obesity rate among countries in South America was primarily fueled by its rapid urbanization instead of trade liberalization, especially considering their deep-rooted protectionism and import substitution industrialization [48]. Currently, approximately, 80% of the region's population lives in cities, making Latin America the world's most urbanized region [49].

Several limitations of this study should be noted. Trade openness could serve as a measure of the presumed consequences of trade liberalization but may not fully capture trade policy. Trade openness can also vary as a consequence of other economic and sociopolitical factors, such as technology and a country's political regime. Therefore, a test of the impact of trade openness cannot be taken as a test of the impact of trade liberalization on the obesity epidemic. Arguably, the openness index is a rather crude measure of trade openness, pertaining to diet and other weight-related health behaviors/outcomes. A more detailed product-level

analysis (e.g., import and export of calorie-dense foods and beverages) could be a more sensible choice, but relevant data are limited. The WHO data on annual country obesity rate were subject to measurement error, and its validity/accuracy could vary by country and region. Because of the exclusive use of country-level aggregate data, study findings are subject to ecological fallacy [50]. There is a possibility of discrepancy in the relationship between economic globalization and obesity at the individual level versus the country level. Country fixed effects regression eliminated confounding bias from factors that remained constant within-country across the study period (e.g., geographical location) but could not control for time-variant unobservable factors (e.g., popular culture and fashion). This study adopted an observational study design. Several important variables that might be correlated with economic globalization and obesity were not included in the regression analyses because of data unavailability and/or substantial incompleteness, such as malnutrition and food security, physical activity and sedentary behavior, social/cultural conservatism, and social norms concerning physical fitness and body shape/size. In the sensitivity analyses, we added a few variables including GDP per capita squared, life expectancy, under-five mortality rate, and years of schooling. These inclusions reduced the effective sample size by over one-fifth because of variable missing values. We also considered the possibility of adding an indicator for country democracy (retrieved from the Center for Systemic Peace) [51], but eventually we had to exclude that variable because of its very large missing proportion (62%).

Findings of this study suggest that policy makers and stakeholders in developing countries may need to pay attention to the negative health externalities such as obesity introduced by economic globalization and find ways to effectively alleviate the problem. In recent years, various policy interventions that aim to combat the obesity epidemic have been tested and/or launched at local or national scale in the United States and other developed countries, such as junk food and soda tax [52], subsidy for healthy food purchase [53], and menu labeling [54]. Some of these policies have also been adopted by developing countries. Evidence on the effectiveness of these policies starts to accumulate, although it remains preliminary to date. A recent evaluation of the impact of excise tax on sugar-sweetened beverage consumption in Berkeley, California, which became the first U.S. jurisdiction to implement soda tax ($0.01/oz) in March 2015, provides encouraging data [55]. For example, consumption rates of sugar-sweetened beverages under the newly imposed soda tax decreased by 21% in Berkeley but increased by 4% in comparison cities without a similar tax [56]. The Mexican government made similar policy changes by implementing an 8% tax on nonessential foods with energy density of 275 kcal or greater per 100 g in January 2014 [56]. Household purchases of taxed foods declined by 5.1% in the first year after implementation [56]. Although menu labeling has not been found to noticeably modify people's diet behavior or reduce energy intake, it holds the potential to motivate the restaurant industry to reformulate products so that they contain less calories and offer more nutritious options [54]. In sum, policy makers in developing countries should closely monitor the changing obesity prevalence in the population during the era of trade liberalization and nutrition transition and consider designing and implementing customized policies to help people maintain a healthy weight.

Conclusion

This study assessed the longitudinal relationship between trade openness and obesity prevalence across 175 countries during 1975—2016. Trade openness was found to be positively associated with country obesity prevalence, and its influence tended to concentrate among developing nations. Policy makers in those countries should closely monitor the evolution in obesity rate during trade liberalization and nutrition transition to minimize its negative impact on weight-related population health. Future studies combining country- and individual-level data with comprehensive measures on the potential correlates of trade openness and weight outcomes are warranted to advance research in this field.

References

[1] Ogden CL, Yanovski SZ, Carroll MD, Flegal KM. The epidemiology of obesity. Gastroenterology 2007;132(6):2087—102.

[2] Hruby A, Hu FB. The epidemiology of obesity: a big picture. Pharmacoeconomics 2015;33(7):673—89.

[3] Nguyen DM, El-Serag HB. The epidemiology of obesity. Gastroenterol Clin North Am 2010;39(1):1—7.

[4] An R. Health care expenses in relation to obesity and smoking among U.S. adults by gender, race/ethnicity, and age group: 1998-2011. Public Health 2015;129(1):29—36.

[5] Behan DF, Cox SH, Lin Y, Pai J, Pedersen HW, Yi M, et al. Obesity and its relation to mortality and morbidity costs. https://www.soa.org/Files/Research/Projects/research-2011-obesity-relation-mortality.pdf. [Accessed 15 February 2019].

[6] Danaei G, Ding EL, Mozaffarian D, Taylor B, Rehm J, Murray CJ, et al. The preventable causes of death in the United States: comparative risk assessment of dietary, lifestyle, and metabolic risk factors. PLoS Med 2009;6:e1000058.

[7] Finkelstein EA, Trogdon JG, Cohen JW, Dietz W. Annual medical spending attributable to obesity: payer-and service-specific estimates. Health Aff (Millwood) 2009;28(5):w822—31.

[8] An R. Racial/ethnic disparity in obesity among US youth, 1999—2013. Int J Adolesc Med Health 2015;29(4).

[9] Centers for Disease Control, Prevention. Childhood obesity fact. https://www.cdc.gov/healthyschools/obesity/facts.htm. [Accessed 15 February 2019].

[10] NCD Risk Factor Collaboration (NCD-RisC). Trends in adult body-mass index in 200 countries from 1975 to 2014: a pooled analysis of 1698 population-based measurement studies with 19·2 million participants. Lancet 2016;387(10026):1377—96.

[11] Woodward D, Drager N, Beaglehole R, Lipson D. Globalization and health: a framework for analysis and action. Bull World Health Organ 2001;79(9):875—81.

[12] Schrecker T, Labonté R, De Vogli R. Globalisation and health: the need for a global vision. Lancet 2008;372(9650):1670—6.

[13] Huynen MM, Martens P, Hilderink HB. The health impacts of globalisation: a conceptual framework. Glob Health 2005;1:14.

[14] Winters LA, Martuscelli A. Trade liberalization and poverty: what have we learned in a decade? Annu Rev Resource Econ 2014;6:493—512.

[15] Oberlander L, Disdier A-C, Etilé F. Globalisation and national trends in nutrition and health: a grouped fixed-effects approach to intercountry heterogeneity. Health Econ 2017;26:1146—61.

[16] Pang T, Guindon GE. Globalization and risks to health. EMBO Rep 2004;5:S11—6.

[17] Labonté R, Mohindra K, Schrecker T. The growing impact of globalization for health and public health practice. Annu Rev Public Health 2011;32:263—83.

[18] Hudson R. The costs of globalization: producing new forms of risk to health and well-being. Risk Manage 2009;11(1):13—29.

[19] Reardon T, Berdegué J. The rapid rise of supermarkets in Latin America: challenges and opportunities for development. Dev Policy Rev 2002;20:371—88.

[20] Reardon T, Timmer C, Barrett C, Berdegue J. The rise of supermarkets in Africa, Asia, and Latin America. Am J Agric Econ 2003;85(5):1140—6.

[21] Reardon T, Timmer C, Minten B. The supermarket revolution in Asia and emerging development strategies to include small farmers. Proc Natl Acad Sci U S A 2012;109(31):12332—7.

[22] Popkin BM, Thomas R. Obesity and the food system transformation in Latin America. Obes Rev 2018;19(8):1028—64.

[23] Barlow P, McKee M, Stuckler D. The impact of U.S. free trade agreements on calorie availability and obesity: a natural experiment in Canada. Am J Prev Med 2018;54(5):637—43.

[24] Lee H, Duffey KJ, Popkin BM. South Korea's entry to the global food economy: shifts in consumption of food between1998 and 2009. Asia Pac J Clin Nutr 2012;21(4):618—29.

[25] Ng SW, Popkin BM. Time use and physical activity: a shift away from movement across the globe. Obes Rev 2012;13(8):659—80.

[26] Brunelle T, Dumas P, Souty F. The impact of globalization on food and agriculture: the case of the diet convergence. J Environ Dev 2014;23(1):41—65.

[27] Popkin BM. Global nutrition dynamics: the world is shifting rapidly toward a diet linked with noncommunicable diseases. Am J Clin Nutr 2006;84(2):289—98.

[28] Kelly M. The nutrition transition in developing asia: dietary change, drivers and health impacts. In: Jackson P, Spiess W, Sultana F, editors. *Eating, Drinking:*

Surviving. Springer Briefs in Global Understanding. Cham: Springer; 2016. p. 83–90.

[29] Pan A, Malik VS, Hu FB. Exporting diabetes mellitus to Asia: the impact of Western-style fast food. Circulation 2012;126(2):163–5.

[30] Higgs S. Social norms and their influence on eating behaviours. Appetite 2015;86:38–44.

[31] Sturm R, An R. Obesity and economic environments. CA Cancer J Clin 2014;64(5):337–50.

[32] Leamer E. A trade economist's view of U.S. wages and globalization. In: Baldwin R, editor. Trade policy issues and empirical analysis. Chicago, IL: University of Chicago Press; 1988. p. 145–204.

[33] Lang T. Diet, health and globalization: five key questions. Proc Nutr Soc 1999;58(2):335–43.

[34] Hawkes C. Uneven dietary development: linking the policies and processes of globalization with the nutrition transition, obesity and diet-related chronic diseases. Glob Health 2006;2:4.

[35] Blouin C, Chopra M, van der Hoeven R. Trade and social determinants of health. Lancet 2009;373(9662):502–7.

[36] Clark SE, Hawkes C, Murphy SM, Hansen-Kuhn KA, Wallinga D. Exporting obesity: US farm and trade policy and the transformation of the Mexican consumer food environment. Int J Occup Environ Health 2012;18(1):53–65.

[37] Neuman M, Kawachi I, Gortmaker S, Subramanian S. National economic development and disparities in body mass index: a cross-sectional study of data from 38 countries. PLoS One 2014;9(6):e99327.

[38] Miljkovic D, Shaik S, Miranda S, Barabanov N, Liogier A. Globalisation and obesity. World Econ 2015;38:1278–94.

[39] Miljkovic D, de Miranda SH, Kassouf AL, Oliveira FC. Determinants of obesity in Brazil: the effects of trade liberalization and socio-economic variables. Appl Econ 2018;50:3076–88.

[40] World Health Organization. Global Health Observatory (GHO) data. http://www.who.int/gho/ncd/risk_factors/overweight_obesity/obesity_adults/en/. [Accessed 15 February 2019].

[41] The World Bank. Databank. https://data.worldbank.org/indicator. [Accessed 15 February 2019].

[42] The United Nations Inter-agency Group for Child Mortality Estimation. Under-5 mortality rate. https://childmortality.org/data. [Accessed 15 February 2019].

[43] Barro R, Lee J. A new data set of educational attainment in the world, 1950-2010. J Dev Econ 2013;104:184–98.

[44] Vogli R, Kouvonen A, Elovainio M, Marmot M. Economic globalization, inequality and body mass index: a cross-national analysis of 127 countries. Crit Public Health 2014;24(1):7–21.

[45] Goryakin Y, Lobstein T, James WP, Suhrcke M. The impact of economic, political and social globalization on overweight and obesity in the 56 low and middle income countries. Soc Sci Med 2015;133:67–76.

[46] Thow AM, Hawkes C. The implications of trade liberalization for diet and health: a case study from Central America. Glob Health 2009;5:5.

[47] Costa-Font J, Mas N, Navarro-Palau P. Globesity: is globalization a pathway to obesity? London: LSE Health; 2013.

[48] Coatsworth JH, Williamson JG. The roots of Latin American protectionism: looking before the great depression. http://www.nber.org/papers/w8999.pdf. [Accessed 15 February 2019].

[49] Ruel MT. Urbanization in Latin America: constraints and opportunities for child feeding and care. Food Nutr Bull 2000;21(1):12–24.

[50] Idrovo AJ. Three criteria for ecological fallacy. Environ Health Perspect 2011;119(8):a332.

[51] Center for Systemic Peace. Polity IV annual time-series, 1800-2017. http://www.systemicpeace.org/inscrdata.html. [Accessed 15 February 2019].

[52] Wright A, Smith KE, Hellowell M. Policy lessons from health taxes: a systematic review of empirical studies. BMC Public Health 2017;17(1):583.

[53] An R. Effectiveness of subsidies in promoting healthy food purchases and consumption: a review of field experiments. Public Health Nutr 2013;16(7):1215–28.

[54] VanEpps EM, Roberto CA, Park S, Economos CD, Bleich SN. Restaurant menu labeling policy: review of evidence and controversies. Curr Obes Rep 2016;5(1):72–80.

[55] Falbe J, Thompson HR, Becker CM, Rojas N, McCulloch CE, Madsen KA. Impact of the Berkeley excise tax on sugar-sweetened beverage consumption. Am J Public Health 2016;106(10):1865–71.

[56] Batis C, Rivera JA, Popkin BM, Taillie LS. First-year evaluation of Mexico's tax on nonessential energy-dense foods: an observational study. PLoS Med 2016;13(7):e1002057.