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The relationship between joining a US free trade agreement and processed food sales, 2002–2016: a comparative interrupted time-series analysis

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Abstract

Objective: To examine changes in sales of highly processed foods, including infant formulas, in countries joining free trade agreements (FTAs) with the US.

Design: Annual country-level data for food and beverage sales come from Euromonitor International. Analyses are conducted in a comparative interrupted time-series (CITS) framework using multivariate random-effects linear models, adjusted for key confounders: gross domestic product (GDP) per capita, percent of the population living in urban areas and female labor force participation rate. Memberships in other FTAs and investment treaties are also explored as possible confounders.

Setting: Changes are assessed between 2002 and 2016.

Participants: Ten countries joining US FTAs are compared with eleven countries without US FTAs in force; countries are matched on national income level, world region and World Trade Organization membership.

Results: After countries join a US FTA, sales are estimated to increase by: 0·89 (95 % CI 0·16, 1·6; $P = 0{\cdot}016$) kg per capita per annum for ultra-processed products, 0·81 (95 % CI 0·47, 1·1; $P < 0{\cdot}001$) kg per capita per annum for processed culinary ingredients and 0·17 (95 % CI 0·052, 0·29; $P = 0{\cdot}005$) kg per capita under age 5 per annum for baby food. No significant change is estimated for minimally processed foods. In statistical models, large unexplained variations in country-specific trends suggest additional unmeasured country-level factors also impact sales trends following entry into US FTAs.

Conclusions: These findings strongly support the conclusion that joining US FTAs can contribute to detrimental changes in national dietary consumption that increase population risk of non-communicable diseases.

Keywords
Trade
Noncommunicable diseases
Diet
Processed foods
Natural experiment

Recent patterns of global dietary change, referred to as the 'nutrition transition', are characterised by shifts from diets high in complex carbohydrates and fibre towards greater consumption of edible oils, animal fats and sugars, particularly in the form of processed foods[1,2]. Dietary risks, particularly low consumption of whole grains and fruits, and high sodium consumption are leading determinants of morbidity and mortality worldwide through their contribution to the development of a wide range of non-communicable diseases (NCDs)[2,3]. In addition to the macro- and micro-nutrient content of changing diets, the degree of processing of foods and beverages is a focus

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of increasing concern[4,5]. Diets characterised by significant consumption of highly processed products have been found to be nutritionally inferior[6], have higher levels of added sugars[7], are associated with higher BMI[8] and increase risk for cardiovascular diseases[9]. For infants' diets, exclusive breast-feeding for 6 months and complementary feeding until 2 years of age are widely acknowledged to be optimal for health[10], but in recent years, rates of exclusive breast-feeding have remained suboptimal and relatively stable worldwide, while formula sales grew over 40 % between 2008 and 2013[11].

A common trait of highly processed foods, beverages and infant formulas is that most are produced by transnational corporations, and US companies play a dominant role in these industries. Nine of the ten largest transnational food and beverage corporations (TFBCs) (excluding alcohol producers) are US companies[12]. The food service sector, which sells many highly processed products, is also dominated by US companies, four of which are the largest in this sector and together account for 25 % of global sales[13]. Two of the four leading global manufacturers of infant foods, which represent over half of this market, are also US companies[11]. Furthermore, in 1981, the US was the only country to vote against the International Code of Marketing of Breast-milk Substitutes[14].

New trade and investment agreements create market opportunities for TFBCs by facilitating the entry, manufacturing, advertising and sale of products in previously untapped markets. In addition to its relationships through the World Trade Organization (WTO), the US currently has bilateral or multilateral free trade agreements (FTAs) with twenty countries, which entered into force between 1985 and 2012[15], and bilateral investment treaties (BIT) with forty-one countries[16]. The decision by two countries to establish a trade or investment treaty is somewhat idiosyncratic and can be influenced by a variety of factors, including geographic proximity, strategic interests and domestic and international politics; in the US's case, partner countries have often initiated the treaty negotiation process[17]. Furthermore, the content of treaties can vary substantially, but standard practice for US FTAs is to use a recently negotiated FTA as a model for subsequent ones, such that agreements signed in similar years generally contain similar provisions[18]. The treaty negotiation process can take up to several years, but once an agreement enters into force, new tariffs and other conditions take effect immediately and changes to imports, exports and affected business relationships can be expected promptly.

Previous research examining relationships between US trade and investment agreements and consumption of processed foods and beverages found consumption of sugar-sweetened beverages (SSBs) is 60 % higher in countries with a US FTA compared with countries without a US FTA[19]. However, a separate examination of SSBs in Peru following its ratification of a US FTA found no significant difference in sales compared with Bolivia, which has no US FTA[20]. The current study is the first to examine longitudinal trends in several processed food outcomes in multiple US FTA partner countries and one of only a few analyses to use a rigorous non-experimental design to assess the impacts of trade agreements[20–22]. We assess longitudinal changes in the sales of processed foods and beverages, including infant foods, in countries joining a US FTA compared with a set of matched countries with no US FTA in force.

Methods

Study design

The current study uses a matched comparative interrupted time-series design to take advantage of changes in policies to assess any differences in countries with *v.* without the change[23]. We compare twenty-one countries, from 2002 to 2016: ten countries joining a US FTA between 2004 and 2012 (exposed group) and eleven matched countries without a US FTA as of 2016 (unexposed group). Of all twenty countries with a US FTA currently in force, ten could not be included in the exposed group – three of these countries' agreements entered into force before the period of available data and in the other seven countries, no data were available for the outcomes of interest. The post-exposure period in each exposed country was defined as beginning on the date of entry into force of its US FTA. The treaty negotiation process can last several years, but the date of entry into force reflects the time when provisions become enforceable and is therefore most meaningful as the exposure date for the current analysis[24].

Four primary outcomes were examined: total sales of (i) minimally processed foods; (ii) processed culinary ingredients; (iii) ultra-processed products and (iv) baby food. The first three outcomes utilise the classification scheme developed by Monteiro *et al.*, which categorises products based on the 'extent and purpose of food processing.'[25] Table 1 lists these four outcomes and the data elements summed to generate each.

Data sources

Data for all outcomes come from the Euromonitor International Passport Global Market Information Database (GMID), which reports annual retail sales based on data compiled from company reports, industry publications, government statistics and interviews[26]. This dataset is widely used in studies exploring national dietary trends as a proxy for consumption[19–21]. The database covers eighty countries; data for 2002–2016 were available at the time of the current study. All outcomes were measured in kilograms per capita (using only the population under age 5 for baby food). Baby food data from Hong Kong were excluded because extremely high values coincided with an epidemic of infant deaths in China tied to tainted

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Table 1 Composition of study outcomes

Outcome	Data elements*
Minimally processed foods	Eggs; fish and seafood; fruits; meat; nuts; pulses; starchy roots; vegetables
Processed culinary ingredients	Butter and margarine; drinking milk products; oils and fats; other dairy; processed fruits and vegetables; rice, pasta, and noodles; sugar and sweeteners
Ultra-processed products	Baked goods; breakfast cereals; cheese; chocolate confectionary; ice cream and frozen desserts; processed meat and seafood; ready meals; sauces, dressings and condiments; savory snacks; soup; spreads; sugar confectionary; sweet biscuits, snack bars and fruit snacks; yogurt and sour milk products; carbonates; concentrates; juice; ready-to-drink coffee; ready-to-drink tea; sports and energy drinks
Baby food	Baby food (milk formula, prepared, dried and other baby food)

*Definitions of individual product categories (from Euromonitor International) are provided in the online supplementary material.

formula[27], which created abnormally high demand for alternative brands available in Hong Kong.

Key confounders established by the existing literature on the relationship between trade and investment liberalisation and dietary consumption were included as covariates: gross domestic product (GDP) per capita, the proportion of the population living in an urban area (urbanisation rate) and the female labor force participation (FLFP) rate among women aged 15 and older. Covariate data are from the World Bank World Development Indicators[28] (FLFP rate), the United Nations Population Division (UNPOP)[29] (urbanisation rate) and the World Bank (GDP per capita) [30].

Possible confounding due to membership in the following other trade and investment agreement was also explored: US BIT, EU FTA, EU international investment agreement (IIA), Switzerland FTA and Switzerland BIT. Membership in a US BIT is a potential confounder because these agreements liberalise investment opportunities for US corporations, and agreements with the EU or Switzerland may have similar effects because other leading TFBCs are based in these countries. Information on membership in these agreements was obtained from the Office of the US Trade Representative[15], the US Office of Trade Agreements Negotiations and Compliance[16], the European Commission[31], the Switzerland State Secretariat of Economic Affairs[32] and the United Nations Conference on Trade and Development[33,34].

Matching

A limitation of this observational data is non-random assignment of the exposure, that is, countries that enter a US FTA may differ from those that do not[35]. Coarsened exact matching (CEM) is one approach to improve comparability across the groups and strengthen conclusions about causality, by splitting variables into meaningful categories, identifying exact matches on those categories and weighting unexposed units to reflect the number of exposed units with the same set of characteristics[36].

CEM was used to identify matches based on the following variables: world region, country income level and WTO membership status. World Bank classifications were used for region and income level[28]. Of sixty-five unexposed countries with all required data, eleven were matched to the exposed group using these criteria; remaining unexposed countries were excluded from the analysis because they had no match. Table 2 shows the five strata formed by CEM, the matched characteristics and the countries in each. Table 3 provides mean values of all outcome variables and covariates, by exposure group, in the baseline year, 2002.

Table 2 Exposed and unexposed group countries in each of five strata formed by coarsened exact matching

Strata	Region*	Income group*	WTO member	Exposed group countries (year joined US FTA)	Unexposed group countries
1	East Asia and Pacific	High	Yes	Australia (2005), Republic of Korea (2012), Singapore (2004)	Japan, Hong Kong (China SAR), New Zealand
2	Latin America and the Caribbean	High	Yes	Chile (2004)	Uruguay
3	Latin America and the Caribbean	Upper-middle	Yes	Dominican Republic (2007), Peru (2009), Colombia (2012), Costa Rica (2009)	Ecuador, Venezuela, Argentina, Brazil
4	Latin America and the Caribbean	Lower-middle	Yes	Guatemala (2006)	Bolivia
5	Middle East and North Africa	Lower-middle	Yes	Morocco (2006)	Egypt, Tunisia

WTO, World Trade Organization; FTA, free trade agreement.
*Region and income group based on World Bank classifications for fiscal year 2016, using gross national income per capita in US$: low income (≤$1025), lower-middle income ($1026–$4035), upper-middle income ($4036–$12 475), high income (>$12 475)[46].

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Table 3 Baseline characteristics and tests for significant group differences between exposed countries and all unexposed countries and matched unexposed countries

	Exposed (*n* 10)		All unexposed (*n* 65)		Matched unexposed (*n* 11), weighted counts	
	Mean or *n*	SD or %	Mean or *n*	SD or %	Mean or *n*	SD or %
Covariates (in baseline year, 2002)						
Region† (*n*)						
East Asia and Pacific	3		9		3	
Europe and Central Asia	0		38		0	
Latin America and Caribbean	6		6		6	
Middle East and North Africa	1		6		1	
North America	0		0		0	
South Asia	0		2		0	
Sub-Saharan Africa	0		4		0	
$\chi 2$			22·2**		0	
P value			<0·01		1·00	
Income group† (*n*)						
Low income	0		0		0	
Lower-middle income	2		13		2	
Upper-middle income	4		21		4	
High income	4		31		4	
$\chi 2$			0·27		0	
P value			0·88		1·00	
GDP per capita (2011 International $)	$17 078	$15 542	$19 913	$17 155	$16 599	$11 333
Standardised difference in means			0·17		–0·04	
P value			0·62		0·94	
Female labor force participation rate (%)	46·1	10·6	47·9	13·0	50·3	11·3
Standardised difference in means			0·15		0·39	
P value			0·67		0·34	
Population living in urban area (%)	72·6	16·6	63·6	17·9	79·7	15·6
Standardised difference in means			–0·50		0·44	
P value			0·14		0·30	
WTO member†	10	100%	52	80%	10	100%
$\chi 2$			2·4		0	
P value			0·12		1·00	
US bilateral investment treaty in force	1	10%	20	30·8%	4	40%
$\chi 2$			1·9		2·3	
P value			0·17		0·14	
EU free trade agreement in force	1	10%	7	10·8%	0·5	5%
$\chi 2$			<0·1		0·25	
P value			0·94		0·62	
EU international investment agreement in force	3	30%	22	33·9%	4·5	45%
$\chi 2$			0·1		0·50	
P value			0·81		0·50	
Switzerland free trade agreement in force	1	10%	28	43·1%	0	0%
$\chi 2$			4·0*		1·0	
P value			0·05		0·32	
Switzerland bilateral investment treaty in force	6	60%	33	50·8%	6	60%
$\chi 2$			0·30		0	
P value			0·59		1·00	
Outcomes (in baseline year, 2002)						
Minimally processed foods (kg per capita)	219	70	216	78	226	80
Standardised difference in means			–0·03		0·10	
P value			0·92		0·82	
Processed culinary ingredients (kg per capita)	106	39	96	52	105	41
Standardised difference in means			–0·20		–0·03	
P value			0·56		0·95	
Ultra-processed products (kg per capita)	138	78	168	99	147	65
Standardised difference in means			0·30		0·13	
P value			0·37		0·77	

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Table 3 *Continued*

	Exposed (*n* 10)		All unexposed (*n* 65)		Matched unexposed (*n* 11), weighted counts	
	Mean or *n*	SD or %	Mean or *n*	SD or %	Mean or *n*	SD or %
Baby food (kg per capita under 5)‡	5·7	5·0	12	12	5·7	4·3
Standardised difference in means			0·54		<0·01	
P value			0·11		1·0	

WTO, World Trade Organization.
Matched unexposed means and counts for all variables are weighted to reflect the number of exposed countries in each strata (in some cases, weighting results in non-integer counts). Standardised difference in means = (unexposed group mean – exposed group mean)/(combined SD).
Results from two-sided *t* tests (unweighted data) and adjusted Wald tests (weighted data) presented for continuous variables; results from $\chi 2$ tests (unweighted data) and *F* tests (weighted data) presented for categorical and binary variables.
**P* ≤ 0·05; ***P* ≤ 0·01.
†Variable used for matching.
‡Excludes data for Hong Kong.

Outcome models

The impact of joining a US FTA on each of the outcomes was investigated using separate linear regression models. Comparative interrupted time-series analysis relies on the inclusion of a treatment term (in this case, FTA membership) and treatment-year interaction term to compare the pre- and post-exposure level and trend, respectively, in the exposed *v.* unexposed groups[37]. For exposed countries, the FTA membership variable ranged from 0 (before joining) to 1 (after joining), with a fraction reflecting the number of days in force during the year each country's FTA entered into force. Each model incorporated the CEM weights, included potential confounders and had the following basic form:

$$\begin{aligned}\text{Outcome}_{ij} \sim\ & b_0 + b_1(\text{year})_j + b_2(\text{FTA membership})_{ij}\\ & + b_3(\text{FTA membership} \times \text{year})_{ij}\\ & + b_4(\log \text{GDPpc})_{ij} + b_5(\text{urbanization rate})_{ij}\\ & + b_6(\text{FLFP rate})_{ij} + e_{ij}\end{aligned}$$

where i indexes country; j indexes year (2002–2016); b's represent model coefficients and e is the residual error. All covariates were time-varying. Alternative models explored the inclusion of membership in the other trade and investment agreements as additional covariates.

Models for each outcome were built in a forward stepwise manner, starting from a model with only the treatment and control variables described above. First, the optimal way to model the relationship to time was examined by comparing the inclusion of a linear year term and year fixed effects. To account for autocorrelation in the longitudinal data, an exchangeable structure was imposed on the residuals, after examining the shape of the autocorrelation function of each outcome. The best-performing models were selected based on Wald tests, as well as visual inspection of graphs of model-predicted values compared with observed values, by country. Model fit graphs are provided in the online supplementary material (Appendix B). The fit statistics and graphs both supported the year fixed effects model as preferable for all outcomes.

In the second step, three alternative sets of additional terms were tested to capture remaining unexplained country-specific variation: a country random intercept, a country random intercept and country random slope on year and country fixed effects. In models with a random intercept and random slope, an unstructured model was used for the covariance to permit correlation between these two parameters. Graphs of model-predicted values compared with observed values supported the model with a random intercept and random slope as the best-performing for all outcomes.

Sensitivity analyses

Two sensitivity analyses were conducted to examine the impact of modelled or missing data on the estimated treatment effects. First, the minimally processed food outcome model was re-estimated without data from the seven (out of twenty-one) countries for which any data were marked as modelled (data for this outcome only were affected); an additional country (Chile) was also excluded because its only matched unexposed country (Uruguay) was dropped by this process. As a result, this model was estimated with six exposed and seven unexposed countries. Second, the model for ultra-processed products was re-estimated without data for ready-to-drink coffee and ready-to-drink tea because of high missingness in these two products' data.

A third sensitivity analysis was conducted to examine the influence of Venezuela as a member of the unexposed group. Venezuela is experiencing a food shortage, which started with food rationing in 2014[38], possibly making this a poor comparison country for these outcomes. Each of the outcome models was rerun with Venezuela excluded from the unexposed group and the remaining three countries in Venezuela's strata upweighted to account for its removal. All analyses were conducted in Stata 14.2.

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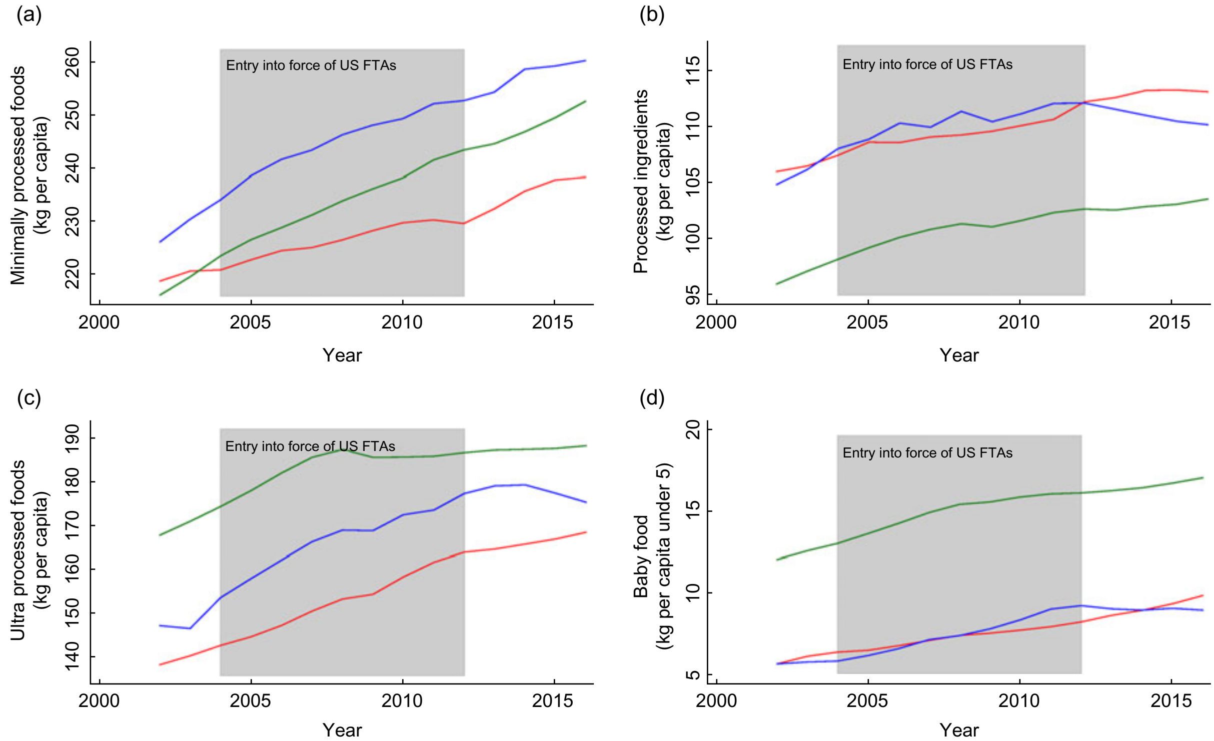

Fig. 1 (colour online) Annual mean per capita sales volumes (unadjusted for covariates) in exposed countries, all unexposed countries and matched unexposed countries (weighted), 2002–2016: (a) minimally processed foods, (b) processed culinary ingredients, (c) ultra-processed products and (d) baby foods. ——, exposed mean; ——, matched unexposed mean; ——, all unexposed mean. FTA, free trade agreements
Range of years of entry into force of US FTAs indicated. Units of the *y*-axes are kilograms per capita (population under age five for baby food and total population for all other outcomes). (Data from Hong Kong excluded for baby food).

Table 4 Model output for annual per capita sales volumes of each outcome

	Minimally processed foods		Processed culinary ingredients		Ultra-processed products		Baby food	
Variable	Coefficients	*P* values	Coefficients	*P* values	Coefficients	*P* values	Coefficients	*P* values
FTA membership	−1·189	0·231	−0·461	0·331	−1·647	0·123	−0·278	0·131
FTA membership × year	−0·222	0·520	0·806***	<0·001	0·888*	0·016	0·173**	0·005
GDPpc (log) (2011 Int $)	11·55*	0·034	23·69***	<0·001	123·1***	<0·001	6·942***	<0·001
Urbanisation rate (%)	1·681***	<0·001	−0·206	0·397	−1·398**	0·003	−0·073*	0·012
FLFP rate (%)	−0·079	0·663	−0·187*	0·034	0·839***	<0·001	0·022	0·363
Year fixed effects?†	Yes		Yes		Yes		Yes	
Intercept	226·8***	<0·001	109·1***	<0·001	164·4***	<0·001	6·898***	<0·001

FTA, free trade agreement; GDPpc, gross domestic product per capita; FLFP, female labor force participation.
All outcomes are measured in units of kilograms per capita, except for baby food, which is measured in units of kilograms per capita under age 5. The covariates gross domestic product per capita, urbanisation rate and FLFP rate are mean-centered to improve the interpretability of the intercepts. Coefficients and *P* values presented for fixed effects.
$^{*}P \le 0{\cdot}05$; $^{**}P \le 0{\cdot}01$; $^{***}P \le 0{\cdot}001$.
†Coefficient values for individual year fixed effects not shown; complete model output available in the online supplementary material.

Results

Figure 1 shows average per capita sales of minimally processed foods, processed culinary ingredients, ultra-processed products and infant foods in exposed, all unexposed and matched unexposed countries, between 2002 and 2016, with the range of years when US FTAs entered into force shaded. These trends indicate that per capita sales of each category of products increased during the study period in both exposure groups, but differences in the rates of growth are noticeable. Sales of minimally processed foods appear to have increased much less rapidly in exposed than in matched unexposed countries. For processed culinary ingredients, ultra-processed products and infant foods, growth rates appear to be slightly greater in exposed countries, particularly during the period after all exposed countries' US FTAs had entered into force.

The model output in Table 4 supports the impacts suggested by the graphs in Fig. 1. In these models, the magnitude and significance of the coefficients on the treatment

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and treatment × year terms indicate any difference in the level and trend, respectively, in each outcome after entry into force of US FTAs in exposed *v.* unexposed countries. Estimated trend changes (treatment × year coefficients) support the study hypotheses, although estimated intercept shifts (treatment coefficients) are more inconsistent and most are not statistically significant. The largest effect of FTA membership is seen for the sales trend of ultra-processed products, estimated to increase by 0·89 (95 % CI 0·16, 1·6; $P = 0{\cdot}016$) kg per capita per annum. Sales of processed culinary ingredients are estimated to increase by 0·81 (95 % CI 0·47, 1·1; $P < 0{\cdot}001$) kg per capita per annum and baby food sales are estimated to increase by 0·17 (95 % CI 0·052, 0·29; $P = 0{\cdot}005$) kg per capita under age 5 per annum. No significant change is estimated for sales of minimally processed foods.

Across all outcomes, the coefficient on GDP per capita is large in magnitude, statistically significant and positive, as expected. For urbanisation and FLFP rate, coefficients are not consistently significant and are mixed in terms of their direction. However, interpretation of the control variable coefficients is complicated by matching because country income level was used as a match variable, GDP per capita coefficients are not entirely meaningful. Likewise, urbanisation and FLFP rate are related to the match variables and, therefore, are also not easily interpretable. The variance of the random intercepts indicates that there is substantial remaining variation across countries that is not captured by other variables in these models.

In alternative model specifications with covariates for membership in other trade and investment agreements, coefficients on these additional control variables were highly inconsistent across outcomes, and estimated effects of US FTA membership on all outcomes were generally slightly smaller in magnitude, but consistent with the main findings. Model fit graphs, additional output and the results of sensitivity analyses examining the impacts of modelled or missing data and the influence of Venezuela as a member of the unexposed group are provided in the online supplementary material. Results from the various sensitivity analyses also supported the main findings, although in the model for ultra-processed products, the treatment × year coefficient lost significance in the model excluding Venezuela.

Discussion

The current analysis is the first to examine the impacts of joining a US FTA on sales of several categories of processed foods in a group of countries over time. The direction and magnitude of estimated changes following entry into a US FTA support a consistent understanding of the way food environments change: sales of ultra-processed products, processed culinary ingredients and infant foods increase annually, while no significant change occurs in the sales of minimally processed foods. Thus, effects are only observed for categories largely comprising of products manufactured, marketed and sold by TFBCs. These results generally confirm findings from earlier research, including a previous study identifying a cross-sectional relationship between higher SSB sales and membership in a US FTA[19]. Furthermore, this supports trade and investment liberalisation as a likely causal mechanism underlying descriptive research showing increases in baby food sales[11] and processed food consumption[39] globally.

Inconclusive results in models controlling for membership in additional trade and investment agreements suggest a need for future research exploring the role of different agreements and partner countries in shaping processed food sales. Across all outcomes, estimated changes in the intercept and slope after entry into a US FTA were often contradictory, which may reflect variation across countries in the speed at which impacts take effect – this is plausible given the variation in retail outlets, distribution systems and other contributing factors across countries. Immediate effects may be difficult to generalise (explaining less significant intercept shifts), but may stabilise over time (as detected by more conclusive trend effects). Large variations in country-specific random intercepts and random slopes suggest additional unmeasured factors are important and that countries do not respond uniformly to joining US FTAs. In addition, all US FTAs examined in the current analysis were treated as identical – distinguished only as not in force *v.* in force. More nuanced future analyses should examine how the impacts of FTAs vary depending on the inclusion of specific commitments and levels of tariff reductions on relevant products, to identify the FTA provisions most relevant to processed food sales.

Overall, the findings of the current analysis have worrying implications for public health. Nutrient-poor products comprise most ultra-processed products and processed culinary ingredients, sales of which were found to increase in US FTA partner countries. Recent research indicates that diets composed of a higher proportion of ultra-processed foods lead to greater total caloric intake, weight gain[40] and increased risk of CVD[9], compared with diets higher in unprocessed foods. Furthermore, there are important implications of increased consumption of highly processed foods for health equity as these changes likely disproportionately impact lower-income groups who are most likely to see the largest increases in highly processed food consumption[41].

These implications support the need to ensure protections for health are included in trade and investment agreements, to mitigate associated declines in the nutritional quality of diets. One possible mechanism is to exempt selected products with negative impacts on public health from market access commitments, to ensure governments have the flexibility to enact policies discouraging their sale and consumption[42,43]. The tobacco carve-out in the original Trans-Pacific Partnership provides a model, but has noted weaknesses that should be improved upon to be more effective[42]. A more comprehensive version of this approach would be to completely exclude specific products or types of regulation from dispute settlement, thereby preventing corporations or other governments from suing governments over policies related to these products. This approach could potentially be expanded to highly processed foods and other products with significant implications for health. Another option is to conduct health impact assessments during the negotiation phase of new agreements, which can identify potential health impacts posed by various provisions and inform ways to alter agreements to mitigate any negative effects[44].

Limitations

An important limitation of the current analysis is the construction of the outcomes, which was limited by the available data. In particular, processed fruits and vegetables could not be disaggregated and did not completely align with one outcome category. Another limitation of these data is that sales are a proxy for consumption, the true measure critical for health.

A fundamental untestable assumption of the CITS analytical approach is that, in the absence of the exposure, differences in trends between groups seen in the pre-period would have continued in the same way into the post-period. We used matching and controlled for known confounders to improve the validity of this assumption, but there may be other extraneous events in exposed or unexposed countries that explain observed differences between the two groups. However, examining multiple countries as opposed to a single exposed–unexposed pair reduces the likelihood that random external factors explain group differences.

Finally, estimated effects may actually underestimate the impacts of joining a US FTA on processed food sales for two reasons. First, four unexposed countries had a US BIT at baseline. This was the variable with the greatest discrepancy between the exposed and matched unexposed countries at baseline (n 1 and n 4, respectively). As a result, unexposed countries' food and beverage markets may be more saturated with US TFBC products than those of countries without a US BIT, thereby attenuating observable differences from exposed countries. Second, some of the impacts of a US FTA may be mediated through increasing household incomes and to a lesser extent through greater urbanisation and women entering the labour force[45]. Including each of these as control variables may capture some indirect effects, thereby diminishing the estimated direct effects of joining a US FTA.

Conclusion

The current analysis contributes new evidence demonstrating that after countries join US FTAs, sales of a range of processed foods and beverages increase. Using a rigorous non-experimental study design, strengthened with matching, we find that following entry into force of a US FTA, countries experience food purchasing trends with generally negative health implications. Estimated average increases are 0·89 kg per capita per annum of ultra-processed products, 0·81 kg per capita per annum of processed culinary ingredients and 0·17 kg per capita under age 5 per annum of infant food. These dietary changes are associated with increased risk of obesity and diet-related NCDs in US FTA partner countries. Additional exploration of country-specific factors mitigating these negative impacts is warranted to develop effective policy responses and design provisions to protect health in future trade and investment agreements.

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Supplementary material

For supplementary material accompanying this paper visit https://doi.org/10.1017/S1368980019003999.

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