Is Mass Media an Effective Channel for Conveying Nutritional Information? Welfare Implications of the WHO Classification of Processed Meats as Carcinogenic on Consumers in Israel

Adam Dvir   Betty Schwartz   Iddo Kan   Israel Finkelshtain

February 2021

Abstract: Disseminating health-information in the mass-media seems like a cost-effective approach to inform the public about the risks involved in consuming hazardous food. But does it work? We answer this question by exploiting the announcement by the World Health Organization (WHO) in October 2015 that processed meat products have been classified as carcinogenic to humans. Our findings are based on two datasets, a representative consumer panel data and aggregated product-level market data of meat purchases in Israel. We apply two different methods of natural-experiments: Regression Discontinuity in Time and Difference-in-Differences, both yield similar results. It turns out that the WHO warning caused a negative, sizable, statistically significant and persistent change in the equilibrium quantities of processed meats, which have dropped by 164 grams per household per month (-18%). To produce an equivalent demand reaction, prices of processed meat would have had to increase by 24%. The effect lasts for at least two years, long after media coverage has faded. The response is affected by income, ethnicity, and education. Low-income households and immigrants from the former USSR did not significantly respond to the announcement. Interestingly, we find that secondary education on the part of one parent is a necessary threshold for reducing long-term consumption. We evaluate two values: (1) the price increase that would have induced processed-meat consumption reduction equivalent to that of the WHO announcement at 3.3-4.05 $/kg, and (2) the marginal expected cancer cost (through illness and mortality) is evaluated at 1.1-4.0 $/kg. As the two ranges overlap, we conclude that the announcement successfully internalized the costs associated with cancer risks into consumers' considerations with respect to consumption of processed meat.

1. Introduction

On October 26th, 2015, the Cancer Agency of the World Health Organization (WHO) issued a dramatic announcement – processed meat products were classified as *carcinogenic to humans*, taking place alongside stigmatized substances proven to be carcinogenic, such as smoking tobacco, arsenic and asbestos (group 1) and red meats where classified as *probably carcinogenic to humans* (group 2A). The experts concluded that each 50 gram portion of processed meat eaten daily increases the risk of colorectal cancer (CRC) by 18%. Governments and international regulatory agencies were advised to conduct risk assessments, to balance the risks and benefits of meat intake.[1] In the weeks that followed, mass media channels spread out the warning as they echo the message to the public worldwide.

[1] The World Health Organization, International Agency for Research on Cancer (2015).

Maintaining a healthy lifestyle and avoiding industrial and processed foods have a considerable impact on public health and on the level of morbidity. There is much epidemiological evidence that links between poor diet, based on industrial and processed food products, and disorders such as heart disease, cancer, stroke, diabetes and obesity.[2] From an economic perspective, providing unhealthy food to consumers who are unaware of the negative consequences of consumption creates an externality, where firms do not account for the full social cost of their products and consumers do not consider the disutility associated with the health risk. Dissemination of the information via the media is a cost-effective means of informing the public of risks. In principle, the nutritional information will drive changes in consumers' behavior, leading to internalization of the externality and to a new equilibrium. But does it work? The objectives of this study are threefold. First, to assess the causal effect of the WHO warning on the quantities of processed meat purchased. Second, to examine whether the effect is heterogeneous and varies with household characteristics, and are certain groups more or less able to act upon this information. Third, to examine whether the announcement caused a decline in consumption to an economically-optimal level, balancing the risks and benefits of meat intake.

[Figure 1 around here]

Figure 1 shows a schematic description of the processed meat market alongside with the predicted effect of the WHO announcement. The marginal cost (MC) line is the competitive price of processed meat ($/kg) ignoring the external cost associated with the health risk. The inverse demand curve (D) is the set of maximal prices that consumers are willing to pay for each additional quantity while they are unaware of the health risk. Prior to the announcement, the equilibrium was set at point "A", the intersection point of MC and D. From a welfare perspective, the equilibrium quantity (Q) is characterized by over-consumption, because the consumers do not take into account the health implications. Following the announcement, both consumers and producers are aware of and internalize the health risk involved in consuming processed meat. Therefore, demand curve drops to D^s, and the new equilibrium is achieved at point "B" with quantity Q^s. Over-consumption of processed meat due to the externality is described by $Q - Q^s$. The blue-painted triangle ADC represents the loss of economic welfare, caused by the fact that both producers and consumers did not internalize the full cost that embodies the health risk, and that market equilibrium is characterized by over-consumption. If producers were to take into account the health implication of their produce, the marginal cost would be MC^s and equilibrium would be achieved at point "C". The additional marginal cost, $MC^s - MC$, represents the

[2] The World Health Organization. Global Status Report (2014).

external marginal cost caused by the consumption of processed meat, which incorporates of shortening of life expectancy, medical care and compensation for suffering as a result of CRC. As one can see, the optimal decrease in demand due to the internalization of the externality by the consumers, is exactly at the point where the equilibrium quantity is equal to the quantity of equilibrium "C". Thus, D^s describes the optimal demand given the external cost of consuming processed meat, and the optimal equilibrium quantity is Q^s. It should be noted that if following the announcement, the decline in demand was sharper so that the actual D^s curve is below and to the left of the D^s curve depicted in the figure, the post-announcement equilibrium is in a state of under-consumption of processed meat, meaning that the WHO announcement, as perceived by the consumers, has exaggerated the damage associated with processed meat consumption. Alternatively, if the decline in demand is too modest so that the actual D^s curve is above and to the right of the depicted D^s curve, the post-announcement equilibrium is in a state of over-consumption of processed meat. Both of these alternatives embody deadweight loss.

It is well documented that consumers do not always internalize the information involved in the consumption of unsafe food. Some of the reasons may be related to the heterogeneity among individuals. First, consumers differ in their preferences toward risk. Consumers with lower risk perception are less likely to respond to warnings regarding health risks (Viscusi et al. 1986). Consumers' response depends also on the cost of risk aversion. This cost is related to the availability of close substitutes. If no close substitutes are available, consumer response would be more moderate (van Ravenswaay 1990; Ferrer and Perrone 2017). Second, consumers differ in their level of attachment to the unsafe food, which is affected by their individual tastes that may be correlated with ethnicity. As standard economic theory predicts, consumers with a higher attachment to the unsafe product are less likely to respond, as the utility loss they experience from giving up the unsafe food is higher. Third, consumers differ in their ability to acquire and assimilate information. Several empirical studies found that consumers who are more exposed to information were more likely to respond to health information warnings (Goode et al. 1996; Shimshack et al. 2007; Verbeke and Ward 2001). A possible proxy for both information acquisition and assimilation is education. One can expect that consumers with higher levels of education will be more responsive to health information warnings than others. Indeed, several studies in the food safety literature find that response is positively correlated with the level of education (Jayachandran et al. 1996, Shimshack et al. 2007, Carrieri and Principe 2018).

Media play a crucial role in determining market response to health information. Coverage is often correlated with the severity of the information and the disclosure of novel scientific evidence (Mazzocchi 2006). The higher the coverage, the bigger the number of people exposed to the information. However, if media coverage is modest, or not heterogeneous across channels and sectors, it is possible that some consumers will not be exposed to the information, and hence would not respond. Finally, the effectiveness of disseminating science-based health information through mass media on the market equilibrium is unclear, since the measurement is complex and affected by many confounders which cannot be easily controlled for.

The effect of health information on the demand for food products, and especially meat products, has been well established in both experimental and empirical studies. The literature dealing with this subject can be classified into two main categories that are integrated to some extent. First, safety incidents, such as food scares and recall events, which are caused in many cases by biological contaminants such as E. coli, salmonellosis and bovine spongiform encephalopathies (BSE). These events tend to follow a certain pattern. The information regarding the contamination becomes public; the news is disseminated by the media in high volume that decreases over time; the public becomes concerned and reacts by decreasing purchases from the contaminated products, until a new equilibrium is reached (Mazzocchi 2006). In most cases, the source of the problem is identified and resolved. The effect of safety incidents on the demand seems to be correlated with the severity of the incident. While several studies pointed out that the effect is relatively modest and does not last long (Flake and Patterson 1999; Dahlgran and Fairchild 2002; Piggott and Marsh 2004; Marsh et al. 2004; Kuchler and Tegene 2006), others found that these kinds of incidents may strongly depress demand in the short term, mainly in cases where safety hazards are severe (Thomsen and McKenzie 2001; Dillaway et al 2011; Pozo and Schroeder 2016). In the case of BSE, which is considered to be more severe than bacterial contamination, evidence of significant long-term effects was also noted (Burton and Young 1996; Verbeke et al. 2000; Schlenker and Villas-Boas 2009).

The second body of literature deals with the ongoing effect of (mainly adverse) health information, on the demand for food products. Unlike safety incidents, which are temporary by nature, this kind of information is mainly related to the nutritional components of the product. Therefore, the risk that involves in its consumption is permanent, and cannot be fully resolved. The source of reliable information comes mostly from epidemiological studies. Prior work has largely found that negative nutritional information regarding cholesterol and fat consumption caused a significant decline in the demand for different foods, such as eggs (Brown and Schrader 1990), saturated-fats oils and butter (Chern et al. 1995) and meat products (Rophe 1992, Kinnucan et al. 1997; Ben Kaabia et al. 2001; Rickertsen et al. 2003; Tonsor and Olynk 2011; Malone and Lusk 2017). One critique of this literature is that results may be driven by specific functional form assumption. Studies using nonparametric-revealed preferences methods find no evidence that health-information has a significant effect on meat consumption (Chalfant and Alston 1988; Rophe 1992), though the power of revealed preference approaches applied to aggregate data remain an open question (Beatty and Crawford 2011). Robenstein and Thurman (1996) exploited red meat future contracts as an alternative to the aggregated demand data. They find no effect of the information on health risks regarding red meat intake, on traders' beliefs about future demand for meat. Other studies (Shimshack et al. 2007; Shimshack and Ward 2010) demonstrated, in the context of methyl-mercury contamination in fish, that the effect of information provision has a strong socioeconomic gradient, where low income and low education consumers may respond differently than affluent and more educated consumers.

In-spite of the large number of researches studying the effect of information on meat demand, few studies have used modern research designs and thus they may not estimate causal effects. The unanticipated WHO announcement can be thought of as a natural experiment with respect to market equilibrium. Under certain conditions this allows us to recover causal estimates. Thus, our study contributes to the literature in understanding how the market internalizes science-based nutritional information and whether internalizing the information leads to a new equilibrium that is economically optimal.

That said, we are not the first to study the effect of the WHO announcement on processed meat market. Unlike us, all previous studies found the effect to be modest. Lehman (2016) found the announcement did not affect the stock market returns of fast food companies or meat producers. Hwang and Moon (2016) consider the Korean market. They find that awareness of the warning lead to increased feeling of guilt regarding meat consumption, which in turn lowered purchases. This study is perhaps closest in spirit to Carrieri and Principe (2018), who studied the effect in Italy, using repeated cross sections of household-level expenditures, comparing time before and after the WHO announcement. While they use Difference-in-Difference framework, as we do, their research design is fundamentally different.[3] They find that the announcement caused a 10% reduction in processed meat expenditures that lasted only a month and that the response was highly heterogeneous. But, Carrieri and Principe (2018) do not control for households' unobserved time invariant characteristics, which may lead to biased estimates of demographic characteristics, such as education. Further, they observe expenditures, while we observe both prices and quantities. This

[3] To control for seasonality, they use household's expenditures in the same month last year. In contrast, we use households' purchases from another category that was not affected by the announcement as a control, as will be further explained below.

is important as focusing on expenditure may obscure the magnitude of any information effect. If prices fall in response to the shock, quantity demanded may increase, offsetting some of the information effect. Using both price and quantity allows us to control for price changes that may highly affect consumption.

The reminder of the paper is organized as follows: Section 2 presents the data; Section 3 describes the natural experiments methods in details; Section 4 discusses the results; Section 5 provides placebo checks and discusses the robustness of the results. Section 6 examines whether the consumers' response to the announcement is economically optimal. At the last section we summarize and conclude.

2. Data

This study utilizes several distinct datasets, detailing the response of consumers to the WHO announcement and spans both pre- and post-announcement periods:

1. Consumer panel data. Our main source of data. It was collected by Nielsen and consists of a representative panel of 2,290 Jewish households.[4] [5] Consumers provide their grocery purchases receipts for the years 2014-2017, which include the Universal Product Codes (UPC) they buy, their prices and quantities, as well as when and where they made purchases. Additionally, the data contain rich demographic information, including household income (by range), size, composition, presence and age of children (by group), marital status, level of religiosity, and ethnicity. It also contains detailed product characteristics for each UPC. The data include processed and red meat categories, along with other categories, such as Yellow Cheese and Fish Conserves. Several strengths of our consumer panel data are worth mentioning. We observe households' revealed preferences including prices and quantities; the data is at the transaction level, which enables to avoid limitations associated with aggregation; the data include all of households' meat purchases, regardless of location.[6] Table 1 shows descriptive statistics of the panel data in the three consecutive years denoted -1, 1, and 2 in relation to the announcement date.

[Table 1 around here]

Table 2 focuses on processed meat, and displays average quantities of processed meat in the three years, broken down to demographics.

[4] The data represent the Jewish population of Israel, which is about 75% of the total population according to the Israeli Central Bureau of Statistics (CBS).

[5] Following Nielsen's recommendation, we left only households that made continuous purchases (regardless of the categories purchased). That is, households that made a purchase at least once a month in 33 of the 38 months on the panel. This, in order to exclude the households that abandoned the panel during the period, or are suspected of not reporting all the purchases they made.

[6] Some scanner-data studies rely on data that was collected only from one food-chain. Therefore, purchases made by households in other food-chains are not taken into account and may be detrimental to the research reliability. Our dataset has a major advantage in comparison to these studies.

[Table 2 around here]

2. Market level purchases. Unlike the consumer panel data, this dataset, also collected by Nielsen, represent the entire population in Israel and include purchases that were made by Arabs. The data include aggregated weekly sales and quantities of the categories sold in the Fast Moving Consumers Goods (FMCG) market in Israel. The data are at the UPC level and consist of four distribution channels (Hypermarkets, Supermarkets, Private Minimarkets and Convenience stores) which are differentiated mainly by store size. The data are based on a sample of stores and is extrapolated by Nielsen to represent the total sales of each UPC in each channel in the FMCG market in Israel.[7] [8]

3. Advertising expenditures. Consist of cost estimations of the marketing campaigns that were funded by the processed-meat producers (and additional categories). The data was collected by Ifat media research.

4. Media-index. The media publications, related to nutritional information regarding the health hazard of meat consumption. The data was also collected by Ifat. To generate the data, we asked Ifat's analysts to collect all media stories that mentioned at least one of the key words: "processed-meat", "red-meat", "sausage" or "pastrami" together with one of the following key words: "cancer", "unhealthy", "disease", "World Health Organization" and "WHO".[9] For each media-story, the estimated value of exposure is given together with additional features, such as the date of publication, medium, source (newspaper, website or channel name), appendage and the title of the article.[10]

3. Methods

To estimate the impact of the WHO announcement on processed meat purchased quantities, we apply a Regression Discontinuity in Time (RDiT) design.[11] We provide additional support for the results by re-estimating the effect using the Difference-in-Differences (DID) methodology with non-meat snacks as a control.

RDiT is a Regression Discontinuity (RD) design, in which time is the running variable and a single point in time differentiates the untreated observations from the treated

[7] The FMCG market in Israel includes: Chain Supermarkets, Hypermarkets, Independent Grocery, and Convenience Stores. Not included: Weekend markets, Drug Stores, Specialty Stores (Delis, Bakeries, Whine shops, etc.), Institutional (hospitals, hotels, etc.), kiosks, Restaurants and Coffee Shops, and Arab Sector Independent Grocery.

[8] Nielsen's panel and market datasets share the same product catalog. This is a major advantage that prevents inconsistencies in findings due to different catalog definitions.

[9] The key words were defined in Hebrew.

[10] The stories were collected from the following media: Internet, newspapers, television and radio. However, Ifat started covering television and radio only in May 2016. Therefore, the data from these media prior to May 2016 are missing.

[11] Hausman and Rapson (2018) offer an RDiT guide for practitioners and outline possible pitfalls.

ones. Despite the resemblance to the cross-sectional RD, there are some differences that need to be taken into account. First, cross sectional RD relies on the assumption that observations within a small neighborhood around the cutoff are similar, and therefore the sample is "as good as random". However, time cannot be thought of as randomly assigned in the small neighborhood surrounding the cutoff. Although treatment may occur at a random point of time, observations in neighboring time points can be correlated with the outcome variable, as time series and especially sales data can be highly seasonal. Therefore, the treatment effect must be isolated from any seasonal confounders that may have occurred at the same time (such as holidays, seasonal picks, weather events etc.). Second, in an RDiT setup the researcher often needs to exploit observations far away from the cutoff, which may infer the "as good as random" assumption (Hausman & Rapson 2018). However, since our identification relies more heavily on the cross sectional variability rather than the period length, this concern becomes less disturbing.

Our underlying identification assumption is that the WHO announcement was strictly exogenous to the Israeli meat market. Although this cannot be explicitly tested, there are several supports to this claim. First, as noted by Ferrer and Perrone (2017), a sharp rise in the media index may be an evidence that the announcement was unexpected. The monthly trend of processed-meat quantities (grams/household/month), in comparison to the media index, is presented in Figure 2.

[Figure 2 around here]

A sharp rise in the media index accompanied by a sharp decline in processed meat quantities can be seen in October and November 2015, immediately after the announcement. The sudden rise in the media index at the exact time of the announcement, and more importantly not before it, suggests that it was unexpected. Second, the announcement came from an international organization, unrelated to the local meat market, so an early leakage of information that could trigger anticipation is less likely.

As noted above, sales data are highly affected by seasonal patterns and holidays. For example, although May and June are consecutive months, meat sales in May are usually substantively higher, due to the Israeli Independence Day which is characterized by barbequing. To deal with the highly seasonal pattern of our sales data, we follow Hausman and Rapson's (2018) Augmented Local Linear Regression Discontinuity design (ARD). The ARD is a two steps procedure, designed to treat the two potential pitfalls related to RDiT described above, controlling for seasonality and relying on observations far away from the cutoff. The first step exploits the entire sample to clean out seasonality and other confounders. To do so meat quantities are regressed on month and holiday dummies, category price index, advertising and household-category fixed effects, using the entire sample period. The first step is estimated using Poisson Pseudo Maximum Likelihood (PPML) because of the non-negative nature of the dependent variable, as further explained below. In the second step, a local linear RD setup is applied using OLS within a narrow bandwidth around the cutoff, where the residuals from the first step are the dependent variable and time is the running variable. To estimate consistent standard errors, the first stage variance is taken into account using a bootstrap procedure. Our local linear RD model include interaction terms to capture the effect of the announcement on different product categories and household demographic groups. The second stage local linear RD specification is:

(1) $Y_{ijt} = \sum_J \sum_d \alpha_{jd}^l \, cat_j \times dem_d + \sum_J \sum_d \beta_{jd}^l \, (m_t - m_0) \times cat_j \times dem_d + \sum_J \sum_d \tau_{jd} D \times cat_j \times dem_d + \sum_J \sum_d (\beta^r - \beta^l)_{jd} D \times (m_t - m_0) \times cat_j \times dem_d + \eta_{ij} + \varepsilon_{ijt}$

In which Y_{ijt} is the first-step residuals of household i in category j at month t. The explanatory variables comprise interactions of the cat_j and dem_d, which are dummy variables indicating categories and demographics respectively, $(m_t - m_0)$ which is the time passage of month m_t from the cutoff month m_0, and the assignment to treatment D, which equals to one in the months following the announcement and zero otherwise. The coefficients include α_{jd}^l, the intercept for category j and demographic group d, β_{jd}^l which represents the slope in the period prior the announcement, $(\beta^r - \beta^l)_{jd}$ is the slope in the period following the announcement, and τ_{jd} is the coefficient of interest that captures the mean causal effect of the announcement on processed meat purchased quantity for category j and demographic group d at the treatment point. In addition, η_{ij} is household-category fixed effects and ε_{ijt} is the error term. Following the local RD literature, we apply different kernel functions and different bandwidths around the cutoff in our ARD setups.

To estimate equation 1 using the Nielsen panel, the quantities were aggregated to the household-month-category level, mainly to reduce the sparsity of the data. Processed meat consists of four categories: "Pastrami and Sausages", "Hot Dogs", "Barbeque Products" and (Ready to Eat) "Schnitzel". Each category includes many UPCs, each with different features that affect its quality and price. Since prices may differ substantively among products, and since we only observe prices of products that were purchased by the households in our sample, in the first step of the ARD procedure we rely on a category price index rather than the observed price as an explanatory variable for quantity. From an econometrical perspective, the category price index can be taken as exogenous, since its generation process keeps quantities at the UPC-channel fixed, ensuring that product quality remains steady and uncorrelated with the error term.[12] Additionally, we control for advertising using the producers' monthly advertising expenditures per category, and for Jewish holidays that may influence meat purchase, such as the Israeli Independence Day, Passover and Shavuot.

As already noted, we provide additional support for the results by re-estimating the effect of the WHO announcement using a Difference-in-Differences (DID) methodology, with the quantities of "Chips Flavor Snacks" category as a control. While meat or protein rich products not mentioned in the WHO notice might seem like a natural control group in the DID design, these products tend to be close substitute of processed meats and might be affected by the WHO warning. The "Chips Flavor Snacks" shares the unhealthy reputation of processed meats, so control for "health trends" that may affect consumption of both categories, but were not the target of the WHO announcement. Identification of a causal effect requires that the purchased quantities trends in both categories would have been the same absent the announcement.

[Figure 3 around here]

Monthly trends of quantity per household for both categories are presented in Figure 3. Purchased quantity in each is influenced by different holidays. Quantities of processed meat increase dramatically at the Israeli Independence Day in May (for many Israelis barbequing is an important part of the celebration) and the quantities of "Chips Flavor Snacks" tend to increase towards Passover (since other snacks are not kosher during Passover), which usually takes place in April.[13] Controlling for these two holidays with fixed effects, the common trend assumption seems to hold. Our DID specification, including category and demographic groups interactions, is:

$$(2) \qquad Y_{ijt} = \sum_J \sum_d \beta_{jd}\, cat_j \times dem_d \times D \;+ \lambda_j + \gamma_t + \delta_i + X_{ijt} \times cat_j \times dem_d + \varepsilon_{ijt}$$

In which Y_{ijt} is the quantity that was purchased by household i from category j at month t; cat_j, dem_d and D are as defined above. λ_j, γ_t, and δ_i are category, month-year and household fixed effects respectively; X_{ijt} are control variables, such as price index, advertising expenditures and holidays; and ε_{ijt} is the error term. The coefficient

[12] The method of calculating the category price index is explained in the appendix.
[13] The Jewish calendar not always fits perfectly with the Orthodox calendar. Therefore, Jewish holidays may shift slightly over years and to occur in neighboring months.

of interest is β_{jd}, which captures the mean causal effect of the announcement on processed meat quantities for category j and demographic group d.[14]

Although quantities were aggregated at the household-category-month level, the data are still very sparse, with about 80% of the observations at zero. Moreover, the dependent variable is non-negative, since a household cannot purchase a negative quantity, therefore OLS estimates are expected to be biased (Tobin 1958). To deal with the non-negativity and sparsity nature of our data, we follow Santos-Silva and Tenreyro (2006, 2011) suggestion of using the Poisson Pseudo Maximum Likelihood (PPML) estimator. The PPML estimator does not require the dependent variable to follow the Poisson distribution, nor being a count variable. The estimator is consistent as long as the conditional mean is correctly specified. The PPML estimator allows for standard errors clustering and (unlike panel data Tobit) to incorporate fixed effects. The PPML is robust to heteroscedasticity and provides a natural way to handle non-negative data where a large proportion of observations are at zero (Santos-Silva and Tenreyro 2006).[15]

4. Results

4.1. The WHO announcement causal effect

We begin with a simple analysis of the quantities of processed meat purchased before and after the WHO warning. Table 3 compares main statistics of processed meat purchases across years.

[Table 3 around here]

Several findings worth noting. First, total quantity (kg) declined by 19% during the first year and continued to decline by additional 3% in the second year while the price index remains unchanged (and even slightly dropped). Second, the decline seems not to be due to an abandonment of processed meat (-3% in both years), but mainly due to a major decline in the number of purchases made by households that continued to purchase (-17% and -19% in years 1 and 2 versus -1 respectively).

We base our findings on two estimation methods (ARD and DID) and on two separate datasets, Panel and Market data collected by Nielsen, as described in detail above. However, we focus on the panel data, which allow to capture a broad demographic gradient and to incorporate household level fixed effects that captures household unobserved time-invariant characteristics, such as idiosyncratic tastes. The ARD

[14] It should be noted that in contrast to many DID studies, in this case, the treatment and control groups are not composed of different households, but of purchases of different categories made by the same household.

[15] Santos-Silva and Tenreyro 2011 show that the PPML estimator well behaves even when the proportion of zeros is very large (more than 0.8).

method is preferred over DID since it does not rely on an arguable control group. With that being said, we rely on the DID results to evaluate the longer-term effect, in the second year following the announcement, which is not captured by the ARD. Overall, the DID results and the market level data results reinforce our main findings. The main results, based on the ARD estimation of Eq. (1) and the Nielsen panel data, are presented in Table 4.

[Table 4 around here]

Two specifications are presented in the table. Specification (1) includes category price index and advertising along with month and holiday dummies as explanatory variables for quantity in the first step. Specification (2) includes only month and holiday dummies. Several findings appear from the table. First, the causal effect of the WHO warning on processed meat quantities is negative and significant in both specifications. Second, all four processed meat categories in both specifications were negatively and significantly affected, suggesting that the warning was comprehensive. We focus on specification (1) that includes the additional explanatory variables, and which is more conservative in terms of the magnitude of the effect. We find that the announcement caused an average reduction of 164 grams per household per month, equivalent to an 18% reduction in the overall processed meat consumption. In terms of product categories, the most affected categories (in percent) are "Hot Dogs" and "Barbecue Products" (-25% and -23% respectively). "Pastrami and Sausages" and "Schnitzel" were less affected (-12% and -17% respectively).

The ARD results based on the Nielsen Market Data are presented in Table 5. Specification (1) was estimated using OLS and specification (2) was estimated using 2SLS, since the price is suspected to be endogenous. The price in each week-UPC-channel was instrumented using the (unweighted) mean price of this UPC in all other channels that week. Channels differ mainly in store size, and national chains often set their pricing and promotion strategies at the sub-chain level, which in many cases equivalent to the Nielsen's channel definition.[16] We therefore believe that prices in other channels can be a good instrument for the observed price, since they are correlated with the price through the marginal cost but are not correlated with specific shocks in other channels. We focus on the second specification, estimated using 2SLS.

[Table 5 around here]

As shown in Table 5, the market data results are very similar to the results obtained from the panel. Overall, the causal effect of the announcement in specification (2) is significant and stands at -18%. All four categories were significantly and negatively affected, with the most affected categories being "Hot Dogs" and "Barbecue Products"

[16] As we have been told by Nielsen and various trade factors in the national chains.

(-23% each), while "Pastrami & Sausages" and "Schnitzel" were less affected (-16%, -10%, respectively).

Another important aspect of the announcement effect is persistency. Figure 4 shows a DID estimation of the treatment effect for each month prior and following the announcement, relative to October 2015 (announcement month) which was omitted. The picture emerging from the chart is clear, while the effects in the months before the announcement are either zero or positive, the effects in the months following the announcement are all significant and negative (except in May 2016, due to the Independence Day). We can therefore conclude that the effect of the announcement on processed meat consumption is persistent and lasts for at least two years.

[Figure 4 around here]

4.2. Heterogeneity

Table 6 presents the ARD estimation results of specification (1) of Table 4 in further detail. The first two columns show the overall treatment effect of the announcement on processed meat quantities by different demographic groups, in terms of quantity and percentage. The next pairs of columns show the effect for each of the four categories. The top row displays the overall effect in each category. Below that, each set of three rows displays the average effect of each demographic group and its complementary group (the two groups together include all households), the third row in each set displays the difference in the effect between the two groups.

[Table 6 around here]

The results suggest considerable heterogeneity in the response to the announcement. First, unlike households with higher income, low-income households did not significantly respond to the announcement. The only category in which their response is significant is Hot Dogs. Second, the response is affected by ethnicity. Immigrants from the former USSR did not significantly respond to the announcement (3.5% not significant), unlike non-Russian-immigrants (-22.4% and significant). The reason may be related to cultural differences manifested in a stronger ex-ante attachment to processed meat.[17] Third, households with children reduced their processed meat quantities significantly more than households without children (-245g vs. -127g), but the response in percentages is not significantly different. Overall, we find no evidence that households living in the regional periphery responded differently from households living in the center. This may suggest that the announcement was dramatic enough to be disseminated through the mainstream media, which is accessible everywhere.

[17] The data in our panel show that the quantity of processed meat per capita (kg) purchased by immigrants from the former USSR in the year before the announcement was 36.4% higher than non-Russian-immigrants.

However, in the category of Pastrami & Sausages we do see that households in the periphery responded to a lesser extent (-0.038 vs. -0.179, the difference is significant).

Interestingly, in terms of processed meat as a whole we find only limited evidence to the effect of education on the response to the warning. Households with at least one collage graduate parent responded similarly to households with no collage graduate parents (-15.4% vs. -20.1%, the difference is not significant). This result is still valid when examining each category separately. Similarly, the response of households with only elementary education did not differ significantly from households with higher levels of education (-50.7% vs. -17.5%, the difference is not significant). We find two possible explanations for these unexpected results. First, it may be related to the extensive media coverage that could have helped bridging the gap of information acquisition and assimilation. The second reason may be related to the longer-term effect, which is not taken into account in the local nature of the ARD that relies on a 12-month bandwidth around the cutoff. It is possible that elementary-education households responded to the information when the media coverage was extensive, but with the decline in coverage they gradually returned to their previous habits. Unlike ARD, the DID design allows for an assessment of the longer-term effect (including the second year following the announcement) and the results do tell a different story. Here, elementary-education households did not significantly respond to the announcement.[18] Furthermore, when examining the effect in each category separately, the results in Table 6 show that households with only elementary education did not respond significantly in any of the four processed meat categories. These results are consistent with the DID results and suggest that secondary education on the part of one parent is a necessary threshold for assimilating the information and internalizing the message and hence for reducing long-term consumption.

5. Robustness and Placebo tests

Several placebo checks were conducted to ensure that our ARD results do indeed capture the impact of the announcement on processed meat purchases, and not any other effect. Figure 5 displays placebo coefficients of discontinuities that simulate fake announcement months.

[Figure 5 around here]

It is evident that the only months in which the discontinuity is negative and significant are October, November and December 2015. While October is the month of the announcement and November is the first full month following it, the fact that December shows also negative and significant (although small) discontinuity is somewhat unexpected. However, the response is likely to spread over time, as most

[18] The results are presented in Table A1 in the appendix.

households do not purchase processed meat products at every purchase, and some not even every month. The fact that we do not find any evidence of negative discontinuity prior to the announcement and in the months following December 2015, reinforces the presumption that the reason for discontinuity is indeed the WHO announcement.

Alternatively, our presumption may be challenged on the grounds that the decrease in the quantities of processed meat was not caused by the WHO announcement, but for another unknown reason. If so, it is likely that other food categories would also have been affected for this reason. Figure 6 presents the ARD estimates of the discontinuities in November 2015, for all product categories we observe in the panel.

[Figure 6 around here]

As one can see, apart from the processed and red meat categories, there is only a handful of categories that experienced negative and significant discontinuity in the first month following the announcement. One of these categories is "Packed Salads", which is suspected to be indirectly affected by the warning, as it is known as close supplement to processed meat. In Israel, eating meat and dairy products together is not common, as it is forbidden by Judaism. Therefore, processed meat products are often eaten along with "Packed Salads", which mainly incorporate Hummus and Tahini salads.

Finally, Figure 7 checks whether our panel data ARD results are robust to different bandwidths around the cutoff, and to different kernel functions. The results from all specifications are practically equal, suggesting that the results are highly robust.

[Figure 7 around here]

6. Is the WHO announcement effect economically optimal?

The above analysis shows that the WHO announcement has led to a reduction in the equilibrium consumption quantities. But is the decline in consumption economically-optimal? That is, does it balance the risks and benefits of processed meat intake? To answer this question we compare two values: 1) The marginal cost of reducing consumption, measured by the increase in processed meat price ($/kg) that would have led to the same decrease in equilibrium quantities as the WHO warning; 2) The benefit of reducing consumption, measured by the reduction in indirect costs ($/kg) attributed to the risk of developing CRC.

6.1. The indirect health cost of processed meat consumption

To estimate the indirect cost of processed meat consumption ($/kg), we use a number of epidemiological calculations, based on age-group morbidity and life expectancy tables in Israel, as further explained below. In addition, we use the information provided by the WHO warning to quantify the effect of processed meat consumption on the risk of developing CRC. These calculated metrics are displayed in Table 7. To assess the monetary cost of the disease we rely on previous studies that estimated the illness cost of CRC and the Value of Statistical Life (VSL).

[Table 7 around here]

***The change in the probability of developing CRC per gram of processed meat*:** According to the WHO announcement, "each 50 gram portion of processed meat eaten daily increases the risk of colorectal cancer by 18%". Assuming the effect is linear in the amount of grams consumed, and given the life expectancy in Israel, we can calculate the change in the probability of developing CRC for each gram of processed meat consumed from birth to death. That is:

(4) $\Delta Pg_s = Rwho/LE_s$

In which ΔPg_s is the percentage change in the probability to develop CRC per gram of processed meat consumed at some point in life for gender s; $Rwho$ is the percentage change in the probability to develop CRC as a result of consuming one gram of processed meat on a daily basis, as stated in the WHO warning (i.e. 0.18 / 50); and LE_s is the life expectancy in Israel for gender s in days. Based on the life expectancy in Israel (excluding infants under one year of age), ΔPg_s is 1.227×10^{-7} and 1.177×10^{-7} for Jewish men and Jewish women respectively (see Table 7, row (g)).

Current Probability (CP): The CP method is considered as a realistic estimate of the lifetime risk of getting cancer. It is calculated based on the number of cancer incidents that would arise during a lifetime of hypothetical birth cohort. The calculation accounts for competing mortality risks in each age group using a current life table (Estève et al. 1994). According to Sasieni et al. (2011), when the CP method is used on data containing only first primaries for all individuals, it provides an excellent estimate of lifetime risk and is considered as the 'gold standard' method. The CP calculation is defined as:

(5) $CP_s = \sum_{i=1}^{I} l_{is} \times w_i r_{is}$

In which r_{is} is the age-specific annual incidence rate for gender s in the ith age group; w_i is the width of the ith age group in years; and l_{is} is a survivor function for the rate of survivors in the ith age group and gender s, defined as:

(6) $l_{is} = l_{i-1,s}(1 - d_{is} w_i)$

In Eq. (6) d_{is} is the yearly number of deaths per 1,000 individuals, unnecessarily related to cancer, in each gender and age group; and $l_{i-1,s}$ is the cumulative rate of survivors from the original group of 1,000 individuals in each gender, up to the ith age group. The mean CP in Israel based on the 2013-2017 yearly average number of CRC incidents is 4.42% and 3.80% for Jewish men and Jewish women respectively (Table 7). These rates are very similar to those of the US. According to the publications of the American Cancer Society, the lifetime risk of developing CRC in the United States for the years 2014-2016 is 4.41% and 4.08% for men and women respectively.[19]

Accordingly, we can reuse Eq. (5) to calculate the lifetime risk of dying from CRC, where r_{is} represents the annual number of deaths from CRC for each gender s in the ith age group. The results in Table 7 show that the lifetime risk of dying from CRC in Israel is 2.03% and 1.57% for Jewish men and Jewish women respectively. In the US, the lifetime risk of dying from CRC is 1.83% and 1.68% for men and women respectively.[20]

Years of Potential Life Lost (YPLL): YPLL measures the number of years of potential life lost due to premature death of a specific cause, CRC in this case. Although various methods are being used to calculate YPLL (see Gardner and Sanborn 1990) we focus on the calculation of YPLL with respect to life expectancy, which does not include a fixed age limit (Estève et al. 1994). The calculation is defined as follows:

(7) $YPLL_{is} = \sum_{i=1} a_{is} d_{is}$

In which a_{is} is the average life expectancy when death caused by CRC occurs in the ith age group and gender s; and d_{is} is the number of observed deaths caused by CRC in the ith age group for gender s. The results are displayed in Table 7. Based on the 2014-2018 yearly CRC mortality data, and based on the tables of life expectancy in Israel obtained from the Israeli Central Bureau of Statistics (CBS), the total yearly sum of YPLL caused by CRC in Israel is 8,435 and 8,224 years for Jewish men and Jewish women respectively. Accordingly, the number of YPLL per CRC death is 14.9 and 15.3 for Jewish men and Jewish women respectively.

The product of the lifetime risk of dying from CRC and the average number of YPLL by the individuals who have died from CRC is the population mean of YPLL caused by CRC.[21] This value is referred to by Estève et al. (1994) as the "Rate of Years of Life Lost". Thus, the mean YPLL per person due to CRC in the entire population is 0.303 and 0.240 years for Jewish men and Jewish women respectively.

[19] The American Cancer Society.
[20] The American Cancer Society.
[21] Note that the number of YPLL of people who did not die from CRC is zero.

We seek to estimate the indirect cost, in terms of YPLL, related to processed meat consumption. Therefore, we are interested in calculating the change in the population-mean YPLL caused by CRC, for each gram of processed meat consumed at some point in life. To do so, we multiply the population mean YPLL (row (f) of Table 7) by the change in the probability of developing CRC per gram of processed meat intake from Eq. (4). The results, presented in the last row of Table 7, are 3.72×10^{-8} and 2.83×10^{-8} years per gram of processed meat, consumed at some point in life, for Jewish men and Jewish women respectively.

Next, we are interested in estimating the monetary cost of the disease. This cost consists of the cost of the years of potential life lost due to premature death and of the cost of the disease and is presented in Table 8.

[Table 8 around here]

Value of Statistical Life (VSL): To assess the cost of premature death one must first evaluate the value of life. The VSL reflects the monetary value associated with one expected fatality in a large population (Viscusi and Masterman 2017). This value is often used as an economic metric that reflects the maximum expense that the society is willing to spend in order to save one human life. While several methods are used to calculate VSL, the most extensive work rely on the labor market contracts. In this literature the tradeoff between the risk of getting physically hurt on the job and the wage compensation that reflects that risk is estimated and converted to VSL. Viscusi (1993) finds that most surveyed studies fall within a $5.2-$12.4 (USD, 2015) million range.[22] An important part of estimating VSL is the income elasticity, because if it is known it can be exploited to convert VSL estimated in one country (mainly US) to another. The theory suggests that income elasticity in respect to VSL should be positive, so VSL in high-income countries is expected to be higher than low-income countries. Meta-analyses of VSL estimates throughout the world imply that point estimates are around 0.5 (Viscusi and Aldy 2003; Mrozek and Taylor 2002). Accordingly, in a meta-analysis of 950 VSL estimates Viscusi and Masterman (2017) find that income elasticity within the United States is indeed 0.5-0.7, however for non-U.S countries is just above 1.

There have been several attempts to estimate the VSL in Israel. Shmueli and Nissan-Engelchin (2008) surveyed previous work that estimated VSL based on labor market, road safety projects, and US based researches. They find two distinct ranges of VSL: $1.6-$2.2 million and $5.0-$6.3 million.[23] Based on these findings, they suggested a

[22] From now on all monetary values are in 2015 US dollars terms.
[23] The original value is 5-7 and 16-20 million (NIS, 2005). It was converted to US dollars at the average exchange rate for 2005 of 3.8858.

VSL equals to the geometric mean of $3.1 million. Viscusi and Masterman (2017) suggest that the best way to calculate VSL in non-US countries is by converting VSL from the US, calculated using labor market estimates, with adjustments for differences in income between the two countries using income elasticity of 1. Their estimate for VSL in Israel is $6.15 million. This estimate is in line with the larger range of VSL surveyed by Shmueli and Nissan-Engelchin (2008). Therefore, we can conclude that the VSL in Israel ranges from $3.1-$6.3 million, where our preferred value is $6.15, as found by Viscusi and Masterman (2017).

Illness cost: The illness cost of CRC consists of direct cost, mainly medical treatment, and an indirect cost that includes loss of productivity and informal care. There are quite a few studies who assess the cost of CRC in the literature. The vast majority of the researches focused on the direct medical care costs, which mainly consist of surgical procedures, radiotherapy and chemotherapy, hospitalization, nursing, medication, and palliative care. Several factors have been found to affect the costs of medical care. First, the costs are highly affected by the different stages of the disease. While the cost is high in the first and last year of disease, the annual cost of the "continuing" phase between them, which sometimes lasts several years, is relatively low.[24] Second, the illness cost associated with younger patients is higher than elderly patients, mainly due to longer survival (Howard et al. 2009; Etzioni et al. 2001; Zheng et al. 2016). Finally, the illness cost of rectal cancer is higher than colon cancer (Maroun et al. 2003; Delcò et al. 2005). A brief summary of the studies that estimated the CRC medical cost is presented in Table A2 in the appendix. Although all cost estimations are of the same order of magnitude, there are significant differences among them. The differences can be due to variability in the quality of medical treatment, the methodologies applied, the period in which the study was conducted and more. However, even studies that used the same sources got significantly different results (see Brown et al. 1999 and Etzioni et al. 2001). Therefore, to take into account the uncertainty regarding the "true" cost of medical care we use three separate values in our calculations. An average estimate of $50,988 (standard deviation of $20,747), a lower bound of $20,808 and an upper bound of $88,564, which are the lowest and highest estimates in Table A2 respectively.

Of all the studies reviewed in Table A2, only two estimated the indirect costs of productivity loss. Färkkilä et al. (2015) estimated the illness cost in Finland using a questionnaire regarding informal care and work capacity of more than 500 CRC patients, alongside the direct medical costs. They estimated the cost of productivity loss at 21.8% of the total cost and the cost of informal care, required mainly in the

[24] Costs can be graphically described over time as a "U" shape.

palliative care phase, at 15.1% of the total cost (36.9% all together). Zheng et al. (2016) used the 2008-2012 Medical Expenditure Panel Survey data of 540 CRC patients to assess the direct medical cost and productivity loss of CRC patients in the United States. They estimated the share of productivity loss of the total cost at 39.5% and 22.8% for patients aged 18-64 and 65+ respectively. Because most CRC patients are older than 65 at the time of diagnosis, the average share of productivity lost from the total cost is 27.9%.[25] Thus, we believe that an average of 33% share of the total cost can be a reasonable estimate of productivity loss and informal costs combined. The total cost values of CRC that we further use in the analysis are presented in Table 8, and are $76,102, $31,057, $132,185 for the average, lower, and upper bounds respectively.

The indirect cost of processed meat consumption: Table 9 displays the indirect costs ($/kg) of processed meat consumption, calculated based on the estimations above. We estimate the indirect cost as a result of YPLL due to the consumption of one kilogram of processed meat at $2.53 (all populations), ranging from $1.3 to $2.6. Our estimate of the indirect illness cost resulting from each kilogram of processed meat consumed is significantly lower and stands at $0.23, ranging from $0.1 to $0.4. Accordingly, the total indirect costs resulting from each kilogram of processed meat consumed is $2.76, ranging from $1.4 to $3.0.

[Table 9 around here]

6.2. The perceived cost of consuming processed meat

As discussed above, the reduction in processed meat quantities caused by the WHO announcement is a result of households' internalization of the indirect health cost associated with consuming processed meat. Alternatively, an equivalent reduction in quantities could be achieved through price increase. Using the mechanism described in Figure 1, the health cost of processed meat consumption, as perceived by the households, can be revealed from this equivalent price increase. The price elasticity of the demand curve for processed meat plays a crucial role in this simulation. The higher the price elasticity the lower the equivalent price increase. Andreyeva et al. 2010 reviewed 160 researches of major food categories to assess the price elasticity by category. They estimated the mean price elasticity for Beef in the US at 0.75 (95% confidence interval: 0.67, 0.83). Although the beef category is not necessarily equivalent to processed meat, and the price elasticity for differentiated meat products may be different, we use this estimate in our calculations for two reasons. First, According to Andreyeva et al. 2010, they found little variation in elasticity for beef across study designs, although it was the most commonly analyzed food in their

[25] The average share of productivity loss out of the total cost of the disease was calculated using the number of cases in each age group (18-64, 65+) in Israel in the years 2014-2017.

research. That is, this estimate is robust. Second, we found many studies who estimated demand for meat, but we could not find studies who estimated demand for processed meat categories that are equivalent to ours.[26]

The perceived indirect health cost of processed meat, as revealed by the equivalent price increase and based on Andreyeva et al. (2010) price elasticity estimate, is presented in Table 10. The perceived cost at the average elasticity point is 3.6 ($/kg) which is 24.0% of the average price per kg of processed meat in our sample. The 95% confidence interval ranges from 3.3 to 4.1 ($/kg).

[Table 10 around here]

Our null hypothesis is that the effect of the WHO announcement on processed meat consumption is economically optimal. To test it, we compare the perceived cost ($/kg) from Table 10 to the estimate of the indirect cost for a kilogram of processed meat consumed ($/kg) from Table 9. As one can see, the range of the indirect cost for Jewish men ($1.5-$3.4), Arab men ($1.8-$4.0) and Arab women ($1.7-$3.6) overlaps with part of the consumers' perceived cost range ($3.3-$4.1). Thus, we conclude that the WHO warning has led to a successful internalization of the cost associated with the risk of developing CRC and these are taken into consideration as part of consumer considerations with respect to the consumption of processed meat. The new equilibrium following the announcement is therefore economically optimal.

7. Conclusions

The objectives of this study are threefold. First, to measure the casual effect of a change in nutritional information on the behavior of consumers and to assess the effectiveness of mass-media information as a vehicle to restore the efficiency of food markets, in the presences of health-related externality. Two different methods of natural experiments and two distinct datasets were used. All yield similar results. The WHO warning caused a negative, significant and persistent change in the equilibrium quantities of processed meats. Processed meat quantities dropped by 164 grams per household per month (-18%). A set of placebo and robustness checks indicates that the effect is causal and that the results are robust to different methods and specifications. The implication is that mass–media can be an effective channel for conveying nutritional information.

Second, we examined whether the effect is heterogeneous and varies with household characteristics. We find that the response is affected by income, ethnicity and education. Low-income households and Immigrants from the former USSR did not significantly respond to the announcement. In terms of education, we find that

[26] We plan to directly estimate the price elasticity from our data as an extension to this study.

secondary education on the part of one parent is a necessary threshold for internalizing the message and hence for reducing long-term consumption. However, we do not find evidence to the effect of academic education on the response to the announcement. Additionally, households living in the regional periphery did not respond differently from households living in the center. A possible explanation for these findings is that the warning was severe enough to be disseminated through the mainstream media, accessible to everyone everywhere. This might have helped bridge the gap in information acquisition and assimilation.

Third, we examined whether the WHO announcement caused a decline in consumption to an economically-optimal level, balancing the risks and benefits of processed meat intake. In other words, we examined whether the new equilibrium following the announcement fully internalizes the health implications of processed meat consumption. We find that the consumers' perceived cost of the health risk involved in consuming processed meat was within the range of the actual cost of the damage. Therefore, the new equilibrium following the announcement successfully internalizes the indirect costs of processed meat consumption and is hence economically optimal.

References

1. American Institute for Cancer Research, 2018. "Meat, Fish and Dairy Products and the Risk of Cancer". Retrieved from: https://www.wcrf.org/sites/default/files/Meat-Fish-and-Dairy-products.pdf.
2. Andreyeva, Tatiana, Michael W. Long, and Kelly D. Brownell. 2010. "The Impact of Food Prices on Consumption: A Systematic Review of Research on the Price Elasticity of Demand for Food." *American Journal of Public Health*, 100(2).
3. Beatty, Timothy K. M., and Ian A. Crawford. 2011. "How Demanding Is the Revealed Preference Approach to Demand?" *American Economic Review*, 101 (6): 2782-95.
4. Ben Kaabia, Monia, Ana M. Angulu, and José M. Gil. 2001. "Health information and the demand for meat in Spain." *European Review of Agricultural Economics*, 28:499–517.
5. Brown, Deborah J., and Lee F. Schrader. 1990. “Cholesterol Information and Shell Egg Consumption.” *American Journal of Agricultural Economics*, 72: 548–555.
6. Brown, Martin L., Gerald F. Riley, Arnold L. Potosky, and Ruth D. Etzioni. 1999. "Obtaining Long-Term Disease Specific Costs of Care: Application to Medicare Enrollees Diagnosed with Colorectal Cancer." *Medical Care*, 37(12):1249-1259.
7. Burton, Michael, and Trevor Young. 1996. "The Impact of BSE on the Demand for Beef and other Meats in Great Britain." *Applied Economics*, 28: 687–693.
8. Carrieri, Vincenzo, and Francesco Principe. 2020. "WHO and for how Long? An Empirical Analysis of the Consumers' Response to Red Meat Warning." *IZA Discussion Paper No. 13882,* Available at SSRN: https://ssrn.com/abstract=3734750
9. Chalfant, James A., and Julian M. Alston. 1988. “Accounting for changes in Taste.” *Journal of Political Economy*, 96:391–410.
10. Chern, Wen S., Edna T. Loehman, and Steven T. Yen. 1995. “Information, Health Risk Beliefs, and the Demand for Fats and Oils.” *The Review of Economics and Statistics*, 77: 555-564.
11. Corral, Julieta, Xavier Castells, Eduard Molins, Pietro Chiarello, Josep M. Borras, and Francesc Cots. 2016. "Long-Term Costs of Colorectal Cancer Treatment in Spain." *BMC Health Service Research*, 16, 56.
12. Dahlgran, Roger A., and Fairchild Dean G. 2002. “The Demand Impact of Chicken Contamination Publicity – A Case Study.” *Agribusiness*, 18 (4):459–474.
13. Delcò, F., Egger R., Bauerfeind P. and Beglinger C. 2005. “Hospital Health Care Resource Utilization and Costs of Colorectal Cancer during the First 3-Year Period Following Diagnosis in Switzerland.” *Alimentary Pharmacology and Therapeutics* 21 (5):615–622.
14. Dillaway, Robin, Kent D. Messer, John C. Bernard, and Harry M. Kaiser. 2011. “Do Consumers Responses to Media Food Safety Information Last?” *Applied Economic Perspectives and Policy*, 33 (3):363–383.
15. Estève, Jacques, Ellen Benhamou, and Luc Raymond. 1994. "Descriptive Epidemiology" Lyon, France IARC Scientific Publications.
16. Etzioni, Ruth, Scott D. Ramsey, Kristin Berry, and Martin Brown. 2001. “The Impact of Including Future Medical Care Costs when Estimating the Costs Attributable to a Disease: a Colorectal Cancer Case Study.” *Health Economics*, 10(3):245–256.

17. Färkkilä, Niilo, Saku Torvinen, Harri Sintonen, Tiina Saarto, Heikki Järvinen, Juha Hänninen, Kimmo Taari, and Risto P. Roine. 2015. "Costs of Colorectal Cancer in Different States of the Disease." *Acta Oncologica*, 54(4):454–462.
18. Ferrer, Rosa Z. and Helena Perrone. 2017. "Consumers' Costly Responses to product-Harm Crises." *CEPR Discussion Paper No. DP11262.*
19. Flake, Oliver L., and Paul M. Patterson. 1999. "Health, Food Safety and Meat Demand" Contributed paper, American Agricultural Economics Association annual meetings, Nashville, TN.
20. Gardner, John W., and Jill S. Sanborn. 1990. "Years of Potential Life Lost (YPLL)—What Does It Measure?" *Epidemiology*, 1(4):322–329.
21. Goode, Jackie, Alan Beardsworth, Teresa Keil, Emma Sherratt, and Cheryl Haslam. 1996. "Changing the Nation's Diet: a Study of Responses to Current Nutritional Messages." *Health Education Journal*, 55:285-299.
22. Hawng, Seoyoung, and junghoon Moon. 2016. "An Effect of the List of Carcinogenic Food Categories in Consumers' Feelings of Guilt and Purchase Behavior." *Agricultural & Applied Economics Association.* 10.22004/ag.econ.236119.
23. Hausman, Catherine, and David S. Rapson. 2018. "Regression Discontinuity in Time: Considerations for Empirical Applications." *Annual Review of Resource Economics*, 10: 533-552.
24. Howard, David H., Florence K. Tangka, Laura c. Seeff, Lisa C. Richardson, and Donatus U. Ekwueme. 2009. "The Impact of Detection and Treatment on Lifetime Medical Costs for Patients with Precancerous Polyps and Colorectal Cancer." *Health Economics*, 18 (12): 1381–1393.
25. Imbens, Guido W. and Thomas Lemieux. 2008. "Regression Discontinuity Designs: A Guide to Practice." *Journal of Econometrics*, 142: 615-635.
26. Jayachandran, Variyam N., James Blaylock, and David Smallwood. 1996. "A Probit Latent Variable Model of Nutrition Information and Dietary Fiber Intake." *American Journal of Agricultural Economics*, 78 (3): 628–639.
27. Kerrigan, Matthew, Nadia Howlade, Margaret T. Mandelson, Robert Harrison, Edward C. Mansley, and Scott D. Ramsey. 2005. "Costs and Survival of Patients with Colorectal Cancer in a Health Maintenance Organization and a Preferred Provider Organization." *Medical Care*, 43(10): 1043-1048.
28. Kinnucan, Henry W., Hui Xiao, Chung-Jen Hsia, and John D.Jackson. 1997. "Effects of Health Information and Generic Advertising on U.S. Meat Demand." *American Journal of Agricultural Economics*, 79: 13–23.
29. Kuchler, Fred, and Abebayehu Tegene. 2006. "Did BSE Announcement Reduce Beef Purchases?" United States Department of Agriculture Economic Research Service, Report number 34.
30. Lehman, Scott B. 2016. "Stock Market Reactions to the IARC Announcement Linking Red Meat and Processed Meat to Cancer." *Journal of Environmental and Resource Economics*, 3(1).
31. Malone, Trey and Jayson L. Lusk. 2017. "Tastes Trumps Health and Safety: Incorporating Consumer Perceptions into a Discrete Choice Experiment for Meat." *Journal of Agriculture and Applied Economics*, 49 (1): 139–157.
32. Maroun, Jean, Ng Edward, Jean-Marie Berthelot, Christel Le Petit, Simone Dahrouge et al. 2003. "Lifetime Costs of Colon and Rectal Cancer Management in Canada." *Chronic Diseases in Canada*, 24: 91–101.

33. Marsh, Thomas L., Ted C. Schroeder, and James Mintert. (2004). "Impacts of Meat Product Recalls on Consumer Demand in the USA." *Applied Economics*, 36 (9): 897-909.
34. Mazzocchi, Mario. 2006. "No News is Good News: Stochastic Parameters Versus Media Coverage Indices in Demand Models after Food Scares." *American Journal of Agricultural Economics*, 88 (3): 727–741.
35. Mrozek, Janusz R., and Laura O. Taylor. 2002. "What Determines the Value of Life? a Meta-Analysis." *Journal of Policy Analysis and Management*, 21 (2): 253–270.
36. Piggott, Nicholas E. and Thomas L. Marsh. 2004. “Does Food Safety Information Impact U.S. Meat Demand?” *American Journal of Agricultural Economics*, 86:154–74.
37. Pozo, Veronica F., and Ted C. Schroeder. 2016. “Evaluating the Cost of Meat and Poultry Recalls to Food Firms Using Stock Returns.” *Food Policy*, 59:66–77.
38. Rickertsen, Kyrre, Dasi kristofersson, and Lothe Solveig. 2003. "Effects of health information on Nordic meat and fish demand." *Empirical Economics*, 28: 249-273.
39. Robenstein. Rodney G. and Walter N. Thurman. 1996. "Health Risk and the Demand for Red Meat: Evidence from Futures Markets." *Review of Agricultural Economics*, 18(4):629-641.
40. Sasieni, PD, Shelton J, Ormiston-Smith N, Thomson CS, and Silcocks PB. 2011. "What is the Lifetime Risk of Developing Cancer?: the Effect of Adjusting for Multiple Primaries." *British Journal of Cancer*, 105 (3): 460–465.
41. Santos Silva, J. M. C., and Silvana Tenreyro. 2006. “The Log of Gravity.” *Review of Economics and Statistics*, 88, 641–658.
42. Santos Silva, J. M. C., and Silvana Tenreyro. 2011, "Further Simulation Evidence on the Performance of the Poisson-PML Estimator." *Economic Letters*, 112: 220–222.
43. Schlenker, Wolfram, and Sofia B. Villas-Boas, 2009. "Consumer and Market Responses to Mad Cow Disease." *American Journal of Agricultural Economics*, 91:1140-1152.
44. Shimshack, Jay P. and Michael B. Ward. 2010. "Mercury Advisories and Household Health Trade-offs." *Journal of Health Economics*, 29:674-685.
45. Shimshack Jay P., Michael B. Ward, and Timothy K.M. Beatty. 2007. "Mercury Advisories: Information, Education, and Fish Consumption." *Journal of Environmental Economics and Management*, 53:158-179.
46. The American Cancer Society. Retrieved from: <https://www.cancer.org/cancer/cancer-basics/lifetime-probability-of-developing-or-dying-from-cancer.html> (accessed January 27, 2021).
47. The State of Israel, Central Bureau of Statistics. "Deaths from Gastric and Colorectal cancer, by Age Group, Population Group and Sex for 2014-2018." Demography and Census Department, the unit of Health and Natural Movement Statistics. Special processing conducted on 11/25/2020 (available by demand).
48. The State of Israel, Central Bureau of Statistics. "Table 2.3: Population, by Population Group, Religion, Sex and Age." *Statistical Abstract of Israel 2017*. Retrieved from: < https://www.cbs.gov.il/en/publications/Pages/2017/Population-Statistical-Abstract-of-Israel-2017-No-68.aspx>.
49. The State of Israel, Central Bureau of Statistics. "Table 3.25: Life Expectancy at Selected Ages, by Sex and Population Group." *Statistical Abstract of Israel 2018*.

Retrieved from: <https://www.cbs.gov.il/en/publications/Pages/2018/Vital-Statistics-Statistical-Abstract-of-Israel-2018-No-69.aspx>.
50. The State of Israel, Central Bureau of Statistics. "Table 3.26: Mortality Rates per 1,000 Residents, by Age, Population Group and Sex." *Statistical Abstract of Israel 2018*. Retrieved from: < https://www.cbs.gov.il/en/publications/Pages/2018/Vital-Statistics-Statistical-Abstract-of-Israel-2018-No-69.aspx>.
51. The State of Israel Ministry of Health. "Colorectal Cancer in Israel – Updated Mars 2020". Retrieved from: < https://www.health.gov.il/PublicationsFiles/ICR_01032020.pdf>. Data for 2014-2018 were obtained from the Cancer Registry Unit and are available upon demand.
52. The World Bank. "GDP per Capita". Retrieved from: < https://data.worldbank.org/indicator/NY.GDP.PCAP.CD>.
53. The World Health Organization, 2014. "Global Status Report on No communicable diseases". Retrieved from: <https://www.who.int/nmh/publications/ncd-status-report-2014/en/>.
54. The World Health Organization, International Agency for Research on Cancer, 2015. "IARC monographs evaluate consumption of red meat and processed meat", Press Release no. 240. Retrieved from: <https://www.iarc.fr/en/media-centre/pr/2015/pdfs/pr240_E.pdf>.
55. Thomsen, Michael R. and Andrew M. McKenzie. 2001. "Market Incentives for Safe Foods: An Examination of Shareholder Losses from Meat and Poultry Recalls." *American Journal of Agricultural Economics*, 83:526–538.
56. Tobin, James. 1958. "Estimation of Relationships for Limited Dependent Variables." *Econometrica*, 26 (1): 24-36.
57. Tonsor, Glynn T. and Nicole J. Olynk. 2011. "Impacts of Animal Well-Being and Welfare Media on Meat Demand." *Journal of Agricultural Economics*, 62:59–72.
58. Van Ravenswaay Eileen. 1990. "Consumer Perception of Health Risks in Food." Oak Brook, IL, USA: Farm Foundation.
59. Verbeke, Wim, Ronald W. Ward, and Jacques Viaene. 2000. "Probit Analysis of Fresh Meat Consumption in Belgium: Exploring BSE and Television Communication Impact." *Agribusiness*, 16:215–234.
60. Verbeke, Wim, and Ronald W. Ward. 2001. "A Fresh Meat Almost Ideal Demand System Incorporating TV Press and Advertising Impact." *Agricultural Economics*, 25:359–374.
61. Viscusi, Kip W. 1993. "The Value of Risks to Life and Health." *Journal of Economic Literature*, 31(4):1912-1946.
62. Viscusi, Kip W. and Joseph E. Aldy. 2003. "The Value of a Statistical Life: a Critical Review of Market Estimates throughout the World." *Journal of Risk and Uncertainty*, 27(1):5-76.
63. Viscusi, Kip W. and Clayton J. Masterman. 2017. "Income Elasticity and the Global Value of a Statistical Life." *Journal of Benefit-Cost Analysis*, 8(2): 226–250.
64. Viscusi, Kip W., Wesley, A. Magat, and Joel Huber. 1986. "Informational Regulation of Health Risks: an Empirical Evaluation of Hazard Warnings." *Rand Journal of Economics*, 17:351-365.
65. Yabroff, Robin K., Joan L. Warren, Deborah Schrag, Angela Mariotto, Angela Meekins, Marie Topor, and Martin L. Brown. 2009. “Comparison of Approaches for Estimating Incidence Costs of Care for Colorectal Cancer Patients.” *Medical Care*, 47(7):S56–S63.

66. Zheng, Zhiyuan, Robin K. Yabroff, Gery P. Guy Jr, Xuesong Han, Chunyu Li, Matthew P. Banegas, Donatus U. Ekwueme, and Ahmedin Jemal. 2016. "Annual Medical Expenditure and Productivity Loss among Colorectal, Female Breast, and Prostate Cancer Survivors in the United States." *J Natl Cancer Inst.*, 108:djv382.

Hebrew Publications:

67. Rophe, T. 1992. "Structural Changes in the Meat Demand in Israel." (MA thesis). The Hebrew University of Jerusalem, supervised by Finkelshtain I.
68. Shmueli A. and Nissan-Engelchin E. 2008. "A Preliminary Estimate of the Value of Statistical Life in Israel and its Implication to the Technological of the National Health Insurance Package of Benefits." *Economic Quarterly*, 55(4):467-487.

	Year -1	Year 1	Year 2	Year 1 vs. -1 (Pct. Chg.)	Year 2 vs. -1 (Pct. Chg.)
Num. obs.	714,067	701,035	661,564	-0.02	-0.07
Num. of households	2,290	2,290	2,290	0.00	0.00
Num. of purchases	182,030	181,435	173,537	-0.00	-0.05
Num. of purchases per household	79.5	79.2	75.8	-0.00	-0.05
	(38.3)	(37.7)	(36.0)		

Table 1: Nielsen Panel - Summary Statistics

Notes: Data source: Nielsen Panel Data. All periods are equal in length. "Year -1" defined as the first consecutive year prior to the announcement: 26/10/2014 - 25/10/2015, "Year 1" defined as the first consecutive year following the announcement: 26/10/2015 - 25/10/2016, "Year 2" is the second consecutive year following the announcement: 26/10/2016 - 25/10/2017. Standard deviations are shown in parentheses.

Table 2: Processed Meat - Summary Statistics by Demographics

Demographic	Description	Portion	Year -1	Year 1	Year 2
			Quantities conditional on purchase (kg/household)		
All	All Households	1	11.50	9.56	9.20
Low income	Households with a monthly income lower than NIS 4,000	0.08	6.28 (7.69)	5.72 (7.7)	4.96 (7.61)
Russian Immigrant	Households immigrated from the former Soviet Union	0.16	12.02 (13.77)	11.02 (13.75)	10.99 (13.2)
Academic Educ.	At least one collage graduate parent in the household	0.44	11.78 (12.13)	9.90 (11.1)	9.83 (11.27)
Elementary Educ.	No high school graduate parent in the household	0.02	9.51 (9.21)	9.67 (17.12)	7.17 (6.93)
Has Kids	At least one child under the age of 18 lives in the household	0.31	15.49 (15.7)	12.90 (13.87)	12.16 (13.01)
Periphery	Households residing in areas: North, Haifa or South	0.34	12.57 (13.52)	10.78 (12.66)	10.16 (11.94)
Orthodox Jew	A household that defines itself as belonging to the ultra-Orthodox sector	0.11	10.28 (12.37)	8.59 (9.79)	8.34 (9.93)
Num. obs.			54,326	44,032	42,547

Notes: Data source: Nielsen Panel Data. All periods are equal in length. "Year -1" defined as the first consecutive year prior to the announcement: 26/10/2014 - 25/10/2015, "Year 1" defined as the first consecutive year following the announcement: 26/10/2015 - 25/10/2016, "Year 2" is the second consecutive year following the announcement: 26/10/2016 - 25/10/2017. Standard deviations are shown in parentheses.

	Year -1	Year 1	Year 2	Year 1 vs. -1 (Pct. Chg.)	Year 2 vs. -1 (Pct. Chg.)
Total quantity (kg)	24,713	19,929	19,211	-0.19	-0.22
Num. of households that made a purchase	2,148	2,085	2,088	-0.03	-0.03
Num. of purchases	35,998	29,744	29,009	-0.17	-0.19
Quantity per household conditional on purchase (kg)	11.50 (13)	9.56 (11.8)	9.20 (11.1)	-0.17	-0.20
Num. of purchases per household conditional on purchase	16.8 (14.1)	14.3 (13.5)	13.9 (12.9)	-0.15	-0.17
Quantity per purchase (kg)	0.686 (0.72)	0.670 (0.77)	0.662 (0.66)	-0.02	-0.04
*Other variables**			*Average per month*		
Price Index (01/2015=100)	101.43 (1.18)	100.81 (1.05)	101.47 (0.65)	-0.01	0.00
Advertising Expenditures ($ millions)	0.35 (0.35)	0.29 (0.19)	0.23 (0.23)	-0.16	-0.35

Table 3: Summary of Processed Meat Purchases

Notes: Data source: Nielsen panel Data. All periods are equal in length. "Year -1" defined as the first consecutive year prior to the announcement: 26/10/2014 - 25/10/2015, "Year 1" defined as the first consecutive year following the announcement: 26/10/2015 - 25/10/2016, "Year 2" is the second consecutive year following the announcement: 26/10/2016 - 25/10/2017. The price index is calculated on the basis of Nielsen Market Data as described in the appendix. The source of advertising expenditures is Ifat Media Research. Standard deviations are shown in parentheses.

* For these variables a year is defined from November to October of the following year (e.g. Year -1: 11/2014-10/2015).

Table 4: ARD Main Results by Category

	(1)		(2)	
Treatment Effects	g/month	Pct.	g/month	Pct.
Processed Meat	-163.894***	-0.180***	-200.177***	-0.220***
Pastrami & Sausages	-45.625***	-0.124***	-67.679***	-0.184***
Hot Dogs	-42.690***	-0.251***	-53.358***	-0.314***
BBQ Products	-48.453***	-0.230***	-47.994***	-0.227***
Schnitzel	-27.125***	-0.168***	-31.146***	-0.193***
Red Meat	-40.963**	-0.056**	-36.775*	-0.050*
Fresh Red Meat	-48.050***	-0.094***	-59.526***	-0.116***
Frozen Red Meat	7.087	0.033	22.751*	0.105*
Observations	508,380		508,380	
Controls: Months & Holidays	YES		YES	
Controls: Price Ix & Advertising	YES		NO	
Household-Category FEs	YES		YES	
Bandwidth	12 Months		12 Months	
Kernel	Epanechnikov		Epanechnikov	

Notes: The regression coefficients in this table are the estimated causal effect of the WHO announcement on processed and red meat purchased quantity per household, by product category. The regressions were estimated by ARD based on Nielsen panel data. The first stage was estimated using PPML and the second by OLS. Unlike specification (2), specification (1) includes price indices and advertising expenditures at the category-month level as explanatory variables for the quantity in the first stage of the ARD. Standard errors were bootstrapped using 100 repetitions and are clustered at the household-category level. The bandwidth around the cutoff was selected using the "leave-one-out" cross-validation procedure, suggested by Imbens and Lemieux (2008). The results are robust to different bandwidths and kernel functions as shown in Figure 7.
*** p<0.01, ** p<0.05, * p<0.1

Table 5: ARD Results by Category – Total Market Data

Treatment Effects (Pct.)	OLS	2SLS
Processed Meat Total	-0.170***	-0.181***
Pastrami & Sausages	-0.154***	-0.160***
Hot Dogs	-0.223***	-0.232***
BBQ Products	-0.202***	-0.234***
Schnitzel	-0.0992***	-0.101***
Red Meat Total	-0.0244	-0.0129
Fresh Red Meat	-0.0855	-0.0820
Frozen Red Meat	0.149	0.163
Num. Obs. (first stage)	561,302	561,302
Bandwidth	35 weeks	35 weeks
Controls: Price, Advertising & Holidays	YES	YES
Week FEs	YES	YES
UPC-Channel FEs	YES	YES

Notes: The regression coefficients in this table are the causal effect of the WHO announcement on the quantities of processed and red meat purchased in percentage terms, by product categories. The regressions were estimated using ARD based on the Nielsen Total Market data. Both stages were estimated using OLS. Standard errors were bootstrapped using 100 repetitions and are clustered at the UPC-channel level. In the 2SLS specification, the price of each UPC in each channel-week was instrumented using the (unweighted) mean price of the UPC in all other channels that week. The bandwidth around the cutoff was selected using the "leave-one-out" cross-validation procedure, suggested by Imbens and Lemieux (2008). The results are robust to different bandwidth selections and are available upon request.

*** p<0.01, ** p<0.05, * p<0.1

Table 6: ARD Results by Product Categories and Demographic Groups

	Processed Meat									
	Total		Pastrami & Sausages		Hot Dogs		BBQ Products		Schnitzel	
Average Treatment Effects	g/month	Pct.	g/month	Pct.	g/month	Pct.	g/month	Pct.	g/month	Pct.
All	-163.894***	-0.180***	-45.625***	-0.124***	-42.690***	-0.251***	-48.453***	-0.230***	-27.125***	-0.168***
Low Income	-36.436	-0.075	23.025	0.133	-55.214***	-0.503***	17.365	0.116	-21.612	-0.423
Medium and High Income	-175.691***	-0.185***	-51.979***	-0.135***	-41.531***	-0.236***	-54.545***	-0.252***	-27.636***	-0.161***
Difference	139.255**	0.110	75.004***	0.267**	-13.683	-0.266	71.910**	0.368	6.024	-0.262
Russian Immigrant	33.859	0.035	43.573	0.096	3.548	0.017	16.701	0.098	-29.964	-0.207
Non-Russian Immigrant	-201.390***	-0.224***	-62.538***	-0.178***	-51.458***	-0.315***	-60.807***	-0.278***	-26.587***	-0.161***
Difference	235.248***	0.259***	106.111***	0.274***	55.005**	0.332***	77.509***	0.376***	-3.376	-0.046
Academic Educ.	-144.582***	-0.154***	-43.464***	-0.114***	-36.892***	-0.214***	-29.369**	-0.148**	-34.856***	-0.185***
No Academic Educ.	-178.864***	-0.201***	-47.300***	-0.132***	-47.185***	-0.280***	-63.247***	-0.286***	-21.132**	-0.150**
Difference	34.283	0.048	3.836	0.018	10.293	0.066	33.878	0.138	-13.724	-0.035
Elementary Educ.	-368.239**	-0.507**	-202.883	-0.810	-106.028*	-0.557*	-31.667	-0.158	-27.660	-0.325
Educ. Higher than Elementary	-159.891***	-0.175***	-42.544***	-0.115***	-41.449***	-0.244***	-48.782***	-0.231***	-27.115***	-0.166***
Difference	-208.348	-0.332	-160.339	-0.695	-64.579	-0.313	17.115	0.073	-0.546	-0.159
Has Kids	-245.089***	-0.197***	-53.321***	-0.125***	-81.900***	-0.322***	-76.732***	-0.243***	-33.136**	-0.133**
Has No Kids	-126.733***	-0.167***	-42.103***	-0.123***	-24.745***	-0.188***	-35.511***	-0.218***	-24.375***	-0.201***
Difference	-118.356***	-0.029	-11.218	-0.002	-57.155***	-0.134	-41.222*	-0.025	-8.761	0.068
Lives in the Periphery	-158.225***	-0.157***	-15.843	-0.038	-40.377***	-0.194***	-69.432***	-0.296***	-32.573***	-0.224***
Lives in the Center	-166.851***	-0.194***	-61.159***	-0.179***	-43.897***	-0.292***	-37.511***	-0.189***	-24.284***	-0.143***
Difference	8.626	0.036	45.316**	0.141***	3.521	0.098	-31.922	-0.107	-8.289	-0.082
Orthodox Jew	-236.614***	-0.328***	-50.304**	-0.316**	-93.465***	-0.557***	-84.207*	-0.246*	-8.639	-0.166
Non-Orthodox Jew	-154.741***	-0.166***	-45.036***	-0.114***	-36.300***	-0.213***	-43.953***	-0.226***	-29.452***	-0.168***
Difference	-81.873	-0.162*	-5.268	-0.202	-57.165**	-0.344**	-40.254	-0.020	20.813	0.001

Notes: The coefficients in this table are the average treatment effects of the WHO announcement on processed meat purchased quantities per household, by product categories and demographic groups. All coefficients are based on a single regression as specified in Eq. (1) and in Table 4 column (1). Standard errors were bootstrapped using 100 repetitions and are clustered at the household-category level. The regression is weighted by an Epanechnikov kernel.
*** p<0.01, ** p<0.05, * p<0.1

Table 7: Epidemiological measures of CRC morbidity in Israel

	Jewish		Arab		All		
	Male	Female	Male	Female	Male	Female	All
Current Probability (CP)							
(a) CP to develop CRC	0.0442	0.0380	0.0388	0.0311	0.0429	0.0357	0.0390
(b) CP to die from CRC	0.0203	0.0157	0.0161	0.0151	0.0197	0.0157	0.0175
Years of Potential Life Lost (YPLL)							
(c) Avg. # of yearly CRC deaths	564.6	538.3	59.0	55.5	623.5	593.7	1217.2
(d) Avg. # of YPLL	8,434.8	8,223.8	1,233.8	1,245.6	9,668.6	9,469.4	19,138.0
(e) Avg. # of YPLL per CRC death	14.94	15.28	20.92	22.46	15.51	15.95	15.72
(f) Avg. # of YPLL - Pop. mean	0.303	0.240	0.337	0.340	0.306	0.251	0.276
Change in value Per gram of processed meat consumed at some point in life							
(g) Pct. chg. in CP	1.23E-07	1.18E-07	1.29E-07	1.22E-07	1.24E-07	1.20E-07	1.21E-07
(h) Nominal chg. in CP	5.42E-09	4.47E-09	4.98E-09	3.80E-09	5.32E-09	4.28E-09	4.74E-09
(i) Pop. Mean YPLL chg.	3.72E-08	2.83E-08	4.34E-08	4.15E-08	3.79E-08	3.01E-08	3.34E-08

(a) Calculated based on Eq. (5). The data consist of tables by age group, gender and sector, including the number of CRC diagnoses (averaged for 2014-2017), life expectancy, mortality, and the population of Israel in 2016. The source of all tables is the CBS in Israel.
(b) Calculated based on Eq. (5). The number of deaths caused by CRC per year is calculated as an average for 2014-2018. Source: The Israeli CBS.
(c) Averaged for the years 2014-2018. Source: The Israeli CBS
(d) Calculated based on Eq. (7). The data sources are as (a) and (b).
(e) = (d) / (c).
(f) = (b)*(e).
(g) Calculated directly from the WHO announcement based on Eq. (4).
(h) = (a)*(g).
(i) = (f)*(g).

Table 8: Estimations of the Value of Statistical Life and CRC Illness Cost in Israel

	VSL (USD Millions)	Illness Cost (USD Thousands)
Preferred	6.15	48.24
Lower bound	3.10	19.69
Upper bound	6.30	83.80

Notes: Because the illness cost was estimated mainly based on studies in the United States, the values were converted to Israel using the GDP per capita ratio between the two countries in 2015, with an income elasticity of 1.

Table 9: Indirect Cost Estimation of Processed Meat Consumption ($/kg)

	Jewish		Arab		All		
	Male	Female	Male	Female	Male	Female	All
Indirect cost of YPLL due to consumption of processed meat ($/kg) (a)							
Preferred estimate	2.85	2.08	3.48	3.16	2.93	2.25	2.53
Lower bound	1.43	1.05	1.75	1.59	1.48	1.14	1.28
Upper bound	2.91	2.13	3.56	3.24	3.00	2.31	2.59
Illness indirect Cost due to consumption of processed meat ($/kg) (b)							
Preferred estimate	0.26	0.22	0.24	0.18	0.26	0.21	0.23
Lower bound	0.11	0.09	0.10	0.07	0.10	0.08	0.09
Upper bound	0.45	0.37	0.42	0.32	0.45	0.36	0.40
Total indirect Cost due to consumption of processed meat ($/kg)							
Preferred estimate	3.11	2.29	3.72	3.35	3.19	2.46	2.76
Lower bound	1.54	1.13	1.85	1.67	1.58	1.22	1.37
Upper bound	3.37	2.50	3.98	3.56	3.45	2.67	2.99

(a) The values were calculated by multiplying the change in the population-mean YPLL due to CRC per gram of processed meat consumed from the last row of Table 7, by the value of one year of life, derived from the value of VSL in Table 8.
(b) The values were calculated by multiplying the nominal change in CP per gram of processed meat consumed from Table 7, by the illness cost from Table 8.

Table 10: Perceived Indirect Health Cost of Processed Meat Consumption

	Price Elasticity		
	0.67	0.75	0.83
Equivalent price change (pct.)	0.269	0.240	0.217
Perceived cost ($/kg)	4.05	3.62	3.27

Notes: The values in this table were calculated based on the ARD results of Table 6. The price elasticities were taken from Andreyeva et al. (2010). The equivalent price change was calculated against are the average price of processed meat in the Nielsen Panel in the period prior to the announcement.

Table A1: DID Results by Product Categories and Demographic Groups

	Processed Meat									
	Total		Pastrami & Sausages		Hot Dogs		BBQ Products		Schnitzel	
Average Treatment Effects	g/month	Pct.	g/month	Pct.	g/month	Pct.	g/month	Pct.	g/month	Pct.
All	-195.447***	-0.215***	-63.894***	-0.174***	-49.090***	-0.289***	-46.364***	-0.220***	-36.099***	-0.223***
Low Income	-12.687	-0.026	17.298	0.100	-30.745**	-0.280**	-3.169	-0.021	3.929	0.077
Medium and High Income	-212.363***	-0.223***	-71.409***	-0.185***	-50.788***	-0.289***	-50.362***	-0.232***	-39.804***	-0.232***
Difference	199.676***	0.197**	88.707***	0.285***	20.043	0.009	47.193**	0.211	43.733***	0.308
Russian Immigrant	-106.115***	-0.109***	-23.453	-0.052	-54.215***	-0.263***	-9.837	-0.058	-18.610*	-0.129*
Non-Russian Immigrant	-212.385***	-0.236***	-71.562***	-0.203***	-48.119***	-0.295***	-53.290***	-0.244***	-39.415***	-0.239***
Difference	106.270***	0.128***	48.108**	0.152***	-6.096	0.032	43.452***	0.186**	20.805*	0.110
Academic Educ.	-203.822***	-0.217***	-68.312***	-0.179***	-56.273***	-0.327***	-31.125***	-0.157***	-48.111***	-0.255***
No Academic Educ.	-188.955***	-0.213***	-60.469***	-0.169***	-43.523***	-0.258***	-58.176***	-0.263***	-26.787***	-0.190***
Difference	-14.866	-0.004	-7.844	-0.010	-12.750	-0.068	27.051**	0.106*	-21.324**	-0.065
Elementary Educ.	-52.527	-0.072	34.333	0.137	-46.288**	-0.243**	-40.810	-0.204	0.238	0.003
Educ. Higher than Elementary	-198.247***	-0.217***	-65.818***	-0.178***	-49.145***	-0.290***	-46.472***	-0.220***	-36.811***	-0.226***
Difference	145.720	0.144	100.151	0.315	2.857	0.046	5.663	0.016	37.049	0.228
Has Kids	-302.401***	-0.243***	-86.170***	-0.202***	-84.669***	-0.333***	-74.992***	-0.237***	-56.570***	-0.227***
Has No Kids	-146.497***	-0.193***	-53.699***	-0.157***	-32.807***	-0.249***	-33.261***	-0.204***	-26.730***	-0.220***
Difference	-155.904***	-0.049	-32.472**	-0.045	-51.862***	-0.083*	-41.731***	-0.033	-29.839**	-0.007
Lives in the Periphery	-204.068***	-0.203***	-50.770***	-0.121***	-64.018***	-0.308***	-58.153***	-0.248***	-31.127***	-0.214***
Lives in the Center	-190.950***	-0.222***	-70.739***	-0.207***	-41.304***	-0.275***	-40.215***	-0.202***	-38.693***	-0.227***
Difference	-13.117	0.019	19.969	0.085**	-22.714**	-0.033	-17.938	-0.045	7.566	0.013
Orthodox Jew	-270.031***	-0.374***	-37.952**	-0.239**	-62.565***	-0.373***	-122.751***	-0.358***	-46.762***	-0.901***
Non-Orthodox Jew	-186.060***	-0.199***	-67.159***	-0.170***	-47.394***	-0.278***	-36.749***	-0.189***	-34.757***	-0.198***
Difference	-83.971	-0.175*	29.207	-0.068	-15.170	-0.095	-86.002***	-0.169**	-12.006	-0.703**

Notes: The coefficients in this table are the average treatment effect of the WHO announcement on processed meat quantities, by product categories and demographic groups, with "Chips Flavor Snacks" category as a control. The coefficients are based on seven separate regressions, one for each demographic group, and are estimated based on Eq. (2) using PPML. The included control variables are: Price index, advertising, and Holidays, along with household-level fixed effects. The number of obs. in each regression is 592,851. Standard errors are clustered at the household-category level.
*** p<0.01, ** p<0.05, * p<0.

Table A2: Direct Health Cost Estimates of CRC per Patient

Research	Country, Data Source	Sample Characteristics	Cost Period (Following Diagnosis)	Cost Estimation
Brown et al. 1999	USA; SEER-Medicare	N=71,519; Age 65+; Diagnosed in 1983-1993	11 years	$ 55,652
Etzioni et al. 2001	USA; SEER-Medicare	N=71,519; Age 65+; Diagnosed in 1983-1993	11 years	$ 32,806
Howard et al 2009	USA; SEER-Medicare	N=12,473; Age 65+; Diagnosed in 1995-2005	Lifetime	$ 75,295
Yarbroff et al. 2008	USA; SEER-Medicare	N=22,935; Age 65+; Diagnosed in 1973-2002	5 years	$ 88,564
Kerrigan et al. 2005	USA; 2 Insurance plans(b)	N=337; Age 20-64; Diagnosed in 1996-1998	2 years(c)	$ 60,796
Maroune et al. 2003	Canada; Canadian Cancer Registry	N=16,856; Age: not stated; Diagnosed in 2000	Lifetime	$ 20,808
Zheng et al. 2016 (18-64)	USA; MEPS (f)	N=169; Age: 18-64; Diagnosed in 2008-2012	5 years	$ 44,628
Zheng et al. 2016 (65+)	USA; MEPS (f)	N=371; Age: 65+; Diagnosed in 2008-2012	5 years	$ 25,357
Corral et al. 2016	Spain; Hospital del Mar (Barcelona)	N=699; Age: not stated; Diagnosed in 2000-2006	11 years	$ 53,251
Delco et al. 2005	Switzerland; University Hospital of Basel	N=83; Age: not limited; Diagnosed in 1997-1998d	3 years	$ 40,947
Farkkila et al. 2015	Finland; Questionnaire	N=508; Age 26-96; Diagnosed in 2009-2011	5 years(a)	$ 62,766

(a) Assuming that the "Remission" stage takes 3 years, "Rehabilitation" - 1 year, and all other stages 0.5 year.
(b) Two large health insurance plans in Washington state, a preferred provider organization (PPO) and health maintenance organization (HMO).
(c) Patients diagnosed with in situ cancer were excluded. The 2 years period is the extensive part of the disease.
(d) Only patients who underwent intestinal surgery.
(e) The price-level year is not stated. However, we refer to 1998, as this is the last year of the sample.
(f) MEPS - Medical Expenditure Panel Survey

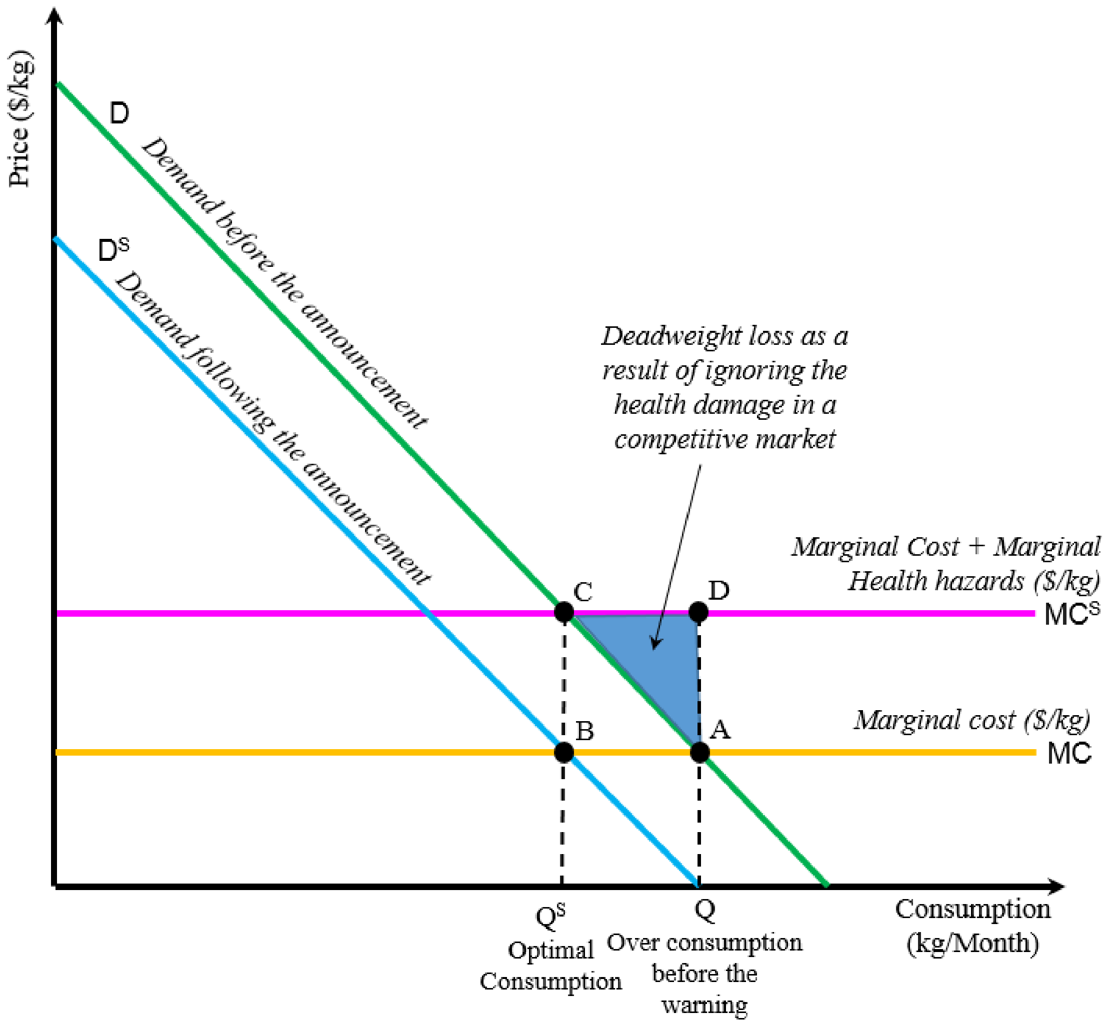
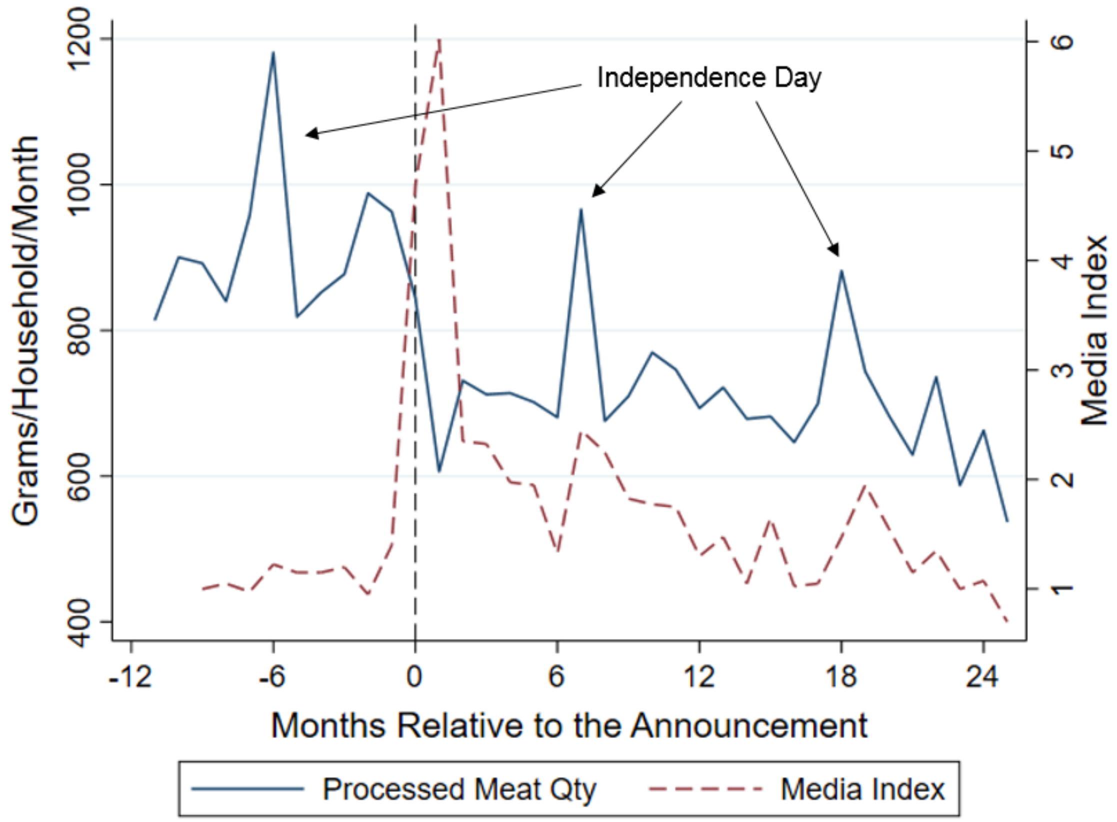
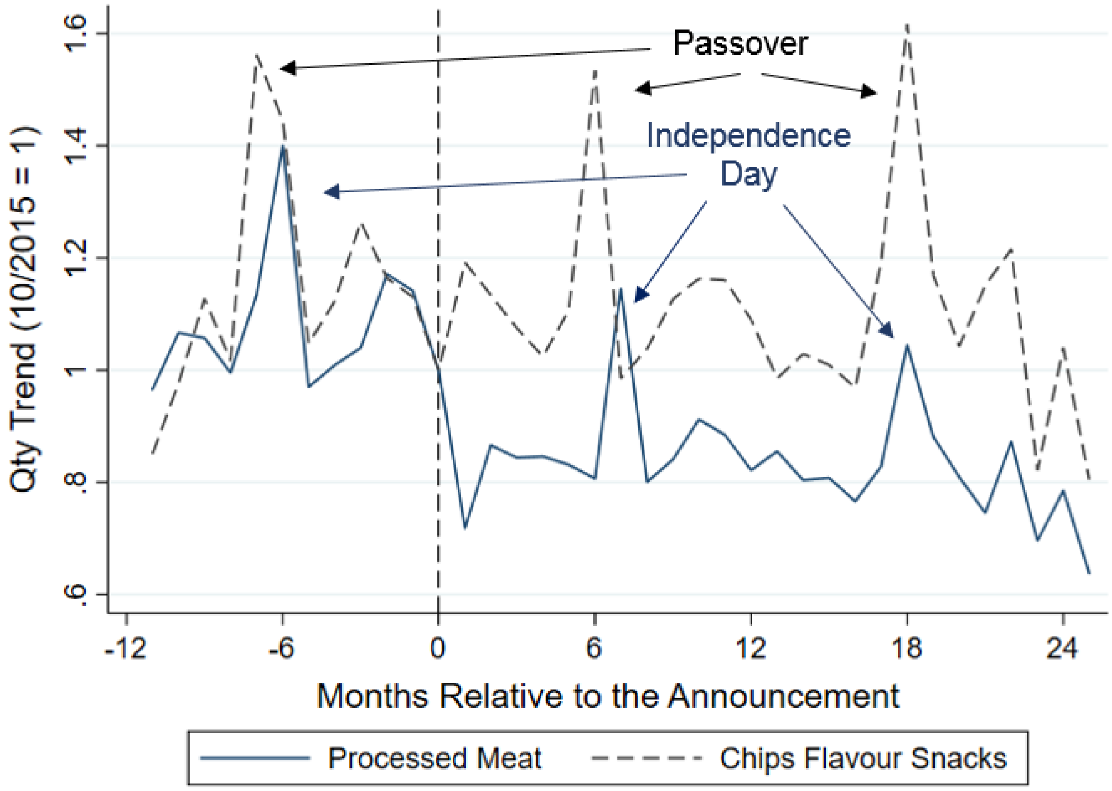


Figure 1: The Effect of the WHO Announcement on the Processed Meat Market



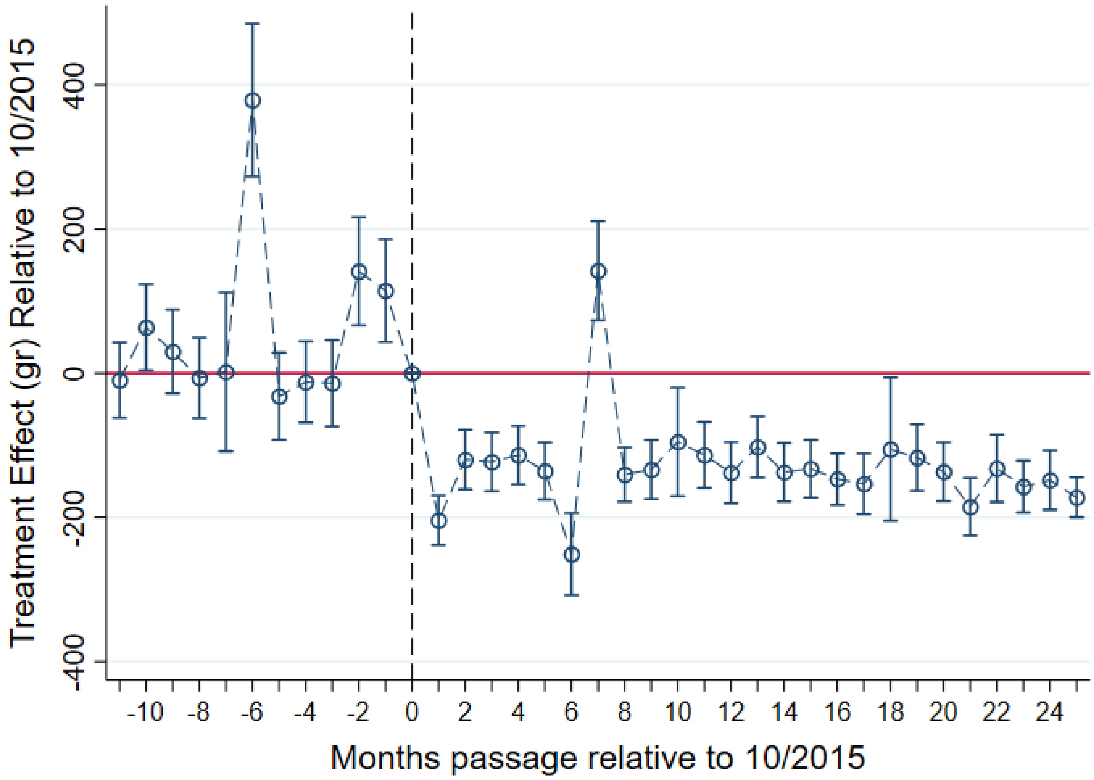
Source: Nielsen Panel Data. The dashed line displays the media index (01/2015=1), which consists of the number of media stories that mentioned at least one of the key words: "processed-meat", "red-meat", "sausage" or "pastrami" together with one of the following key words: "cancer", "unhealthy", "disease", "World Health Organization" and "WHO". Source: Ifat Media Research. Note that the announcement took place on the 26th of October 2015. Therefore, this month includes 6 days of post-announcement period.

Figure 2: Processed meat quantities vs. the media index



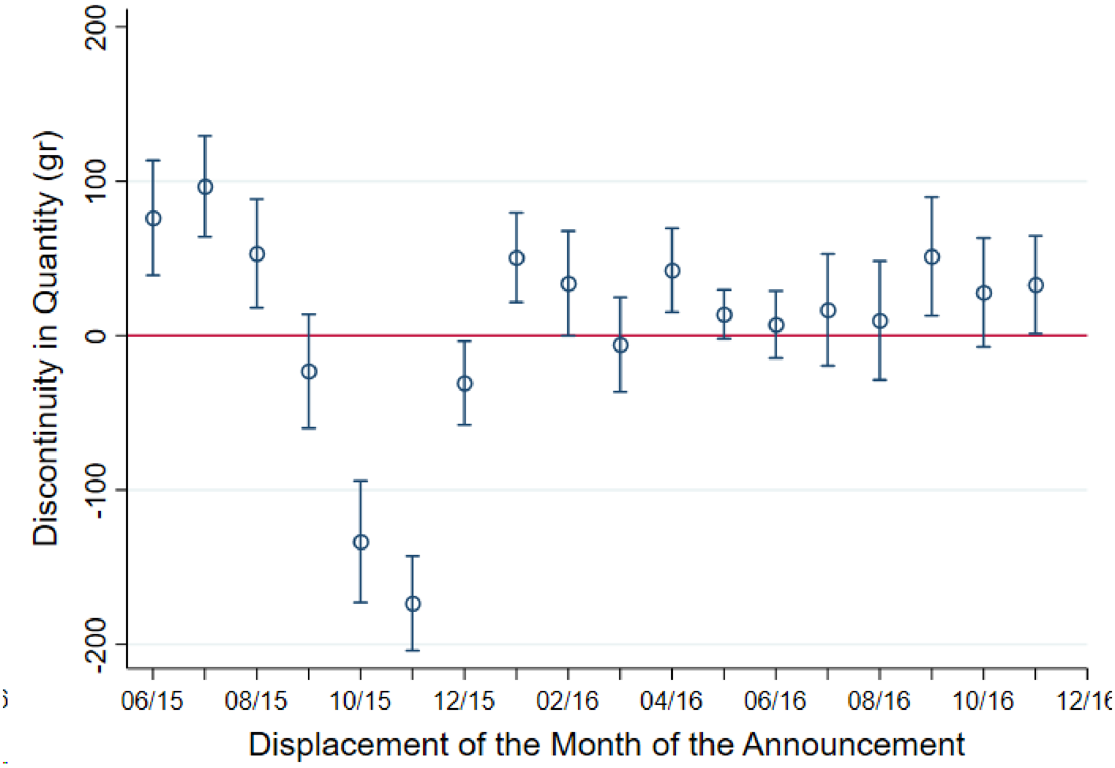
Notes: The trend lines show the monthly change in the quantity per household purchased from the categories of Processed Meat and Chips Flavor Snacks in relation to 10/2015 (announcement month). Source: Nielsen Panel Data.

Figure 3: Monthly trend – Processed Meat vs. Chips Flavor Snacks



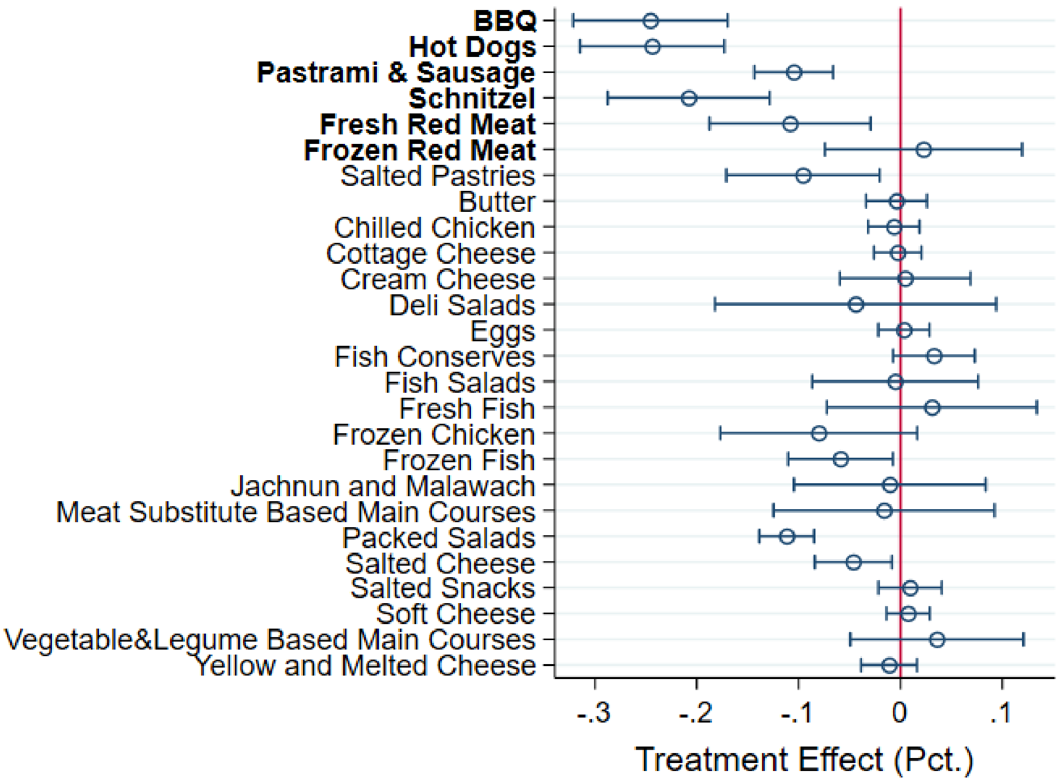
Notes: The chart plots the average monthly treatment effects and 95% confidence intervals of the WHO announcement on the quantities of processed meat per household (g) purchased relative to 10/2015 (announcement month), estimated using DID with "Chips Flavor Snacks" as a control. Data source: Nielsen Panel Data. The regression was estimated using PPML and includes household, month and category fixed effects. Standard errors were clustered at the household level.

Figure 4: Processed Meat Treatment Effect by Month (DID)



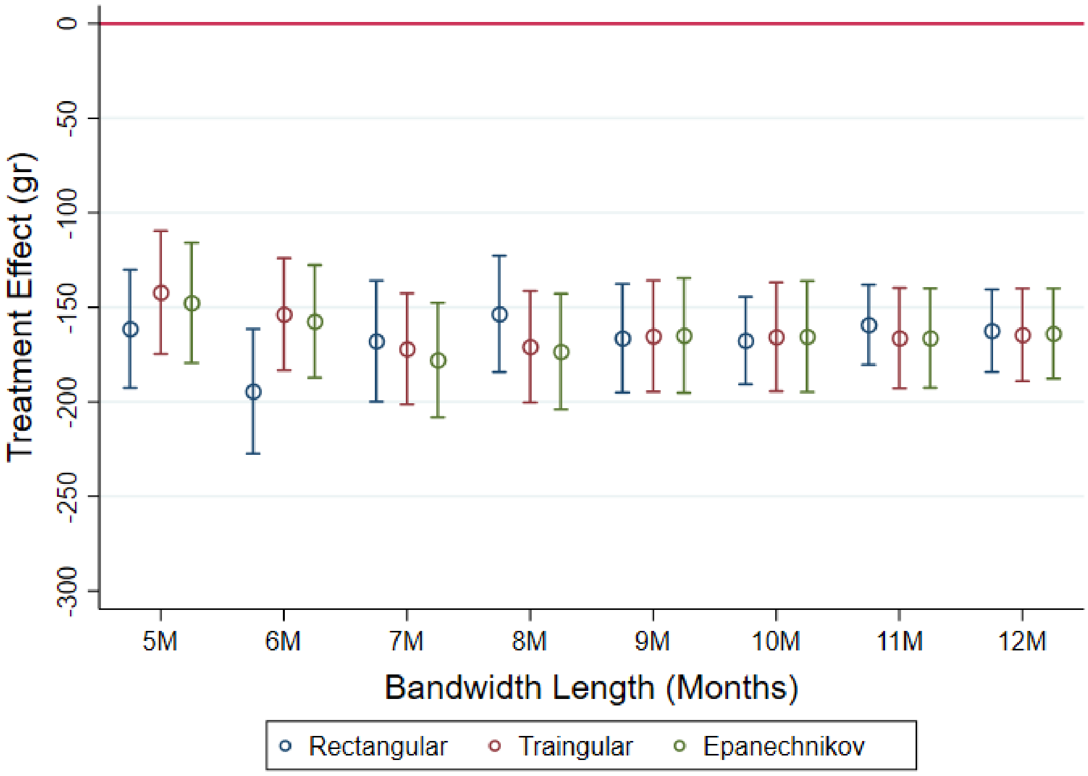
Notes: The figure plots the ARD coefficients of the discontinuity in the dependent variable (g) in 11/2015 (the first month following the announcement) and discontinuities estimated at *t* months displacements from it. The coefficients were estimated separately, using the specification in column (1) of Table 4. The regressions are weighted by an Epanechnikov kernel, with eight months bandwidth around the cutoff. Standard errors were bootstrapped with 100 repetitions and are clustered at the household-category level.

Figure 5: Placebo - Different Announcement Months



Notes: The figure shows the percentage discontinuity coefficients of ARD in 11/2015 (the first month following the announcement) for all product categories available in the Nielsen panel. The regressions were estimated separately using ARD as specified in column (1) of Table 4, with 10 months bandwidth. Standard errors were bootstrapped with 100 repetitions and are clustered at the household level. The regressions are weighted by an Epanechnikov kernel.

Figure 6: Placebo - Different Product Categories



Notes: The figure plots the ARD coefficients of the discontinuity in the average quantity per household (g) of processed meat in 11/2015 (the first month following the announcement), using different bandwidths around the cutoff and different kernel functions. Standard errors were bootstrapped with 100 repetitions and are clustered at the household-category level.

Figure 7: Robustness Check - Treatment Effect by Different Bandwidth and Kernel Functions

8. Appendix

Price Index calculation: To control the effect of UPC-level price changes we calculate a fixed-weight price index for each category and overall. We exploit the Nielsen market data, which consist of weekly data of sales and quantities of all UPCs of processed meat sold during the three years period. The price index calculation procedure requires two definitions: (1) "Branch": The basic level in which the price index is calculated. In this context, a "branch" is defined at the UPC-channel level. Each "branch" consists of a series of monthly prices and a fixed weight that equals to its market share within the "annual series". (2) "Annual series": A period of 13 months, containing all the "branches" with positive sales in that period. The sum of weights of all the "branches" within an "annual series" is equal to one. Because the data period consists of three years, it is divided into three fixed-weight "annual series". The reason for using "annual series" rather than one series for the entire period is because we want to take into account launches of new UPCs that may be of considerable weight and remove UPCs that are no longer sold. [27]

The calculation begins at the "branch" level. For each "branch", the change in the price in each month is calculated in relation to the price of the first month ($\frac{p_m}{p_1}$, where p_m is the price of the "branch" in month m and p_1 is the price of the first month of the "branch"). Note that by definition the index of the first month of each "branch" is 1. At the next stage, all "branches" within each "annual series" are summed according to their fixed weights. The product at the end of this stage is three separate annual price indices starting at 1. At the final stage, the three annual indices are chained into one series of categorical price index. This procedure is performed for each category separately and to processed meat in total. Note that since this is a fixed-weight price index, it only measures changes in prices due to pricing and not due to changes in the underlying quantities.[28] Therefore, changes in the average price that may result from a shift in demand towards more or less expensive products are excluded.

[Table A1 around here]

[Table A2 around here]

[27] The "annual series" lasts 13 months because the first month of each "annual series" is the last month of the previous "annual series" (except of the first "annual series" which lasts 12 months). This allows to chain the separate annual series into one series of the entire period in the last stage.

[28] This statement should be said with caution because a channel consists of many stores and it is possible (although unlikely) that consumer movement to more or less expensive stores within the channel will affect the price, even when product prices have not changed.