Denmark's Policy on Artificial Trans Fat and Cardiovascular Disease

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Introduction: The consumption of trans fat is associated with cardiovascular disease (CVD). In January 2004, Denmark became the first country in the world to regulate the content of artificial trans fat in certain ingredients in food products, which nearly eliminated artificial trans fat from the Danish food supply. The goal of this study was to assess whether Denmark's trans fat policy reduced deaths caused by CVD.

Methods: Annual mortality rates in Organisation for Economic Co-operation and Development (OECD) countries from 1990 to 2012 were used to estimate the effect of Denmark's food policy on CVD mortality rates. Synthetic control methods were employed to simulate the CVD mortality trajectory that Denmark would have witnessed in the absence of the policy and to measure the policy's impact on CVD mortality rates. Analyses were conducted in 2015.

Results: Before the trans fat policy was implemented, CVD mortality rates in Denmark closely tracked those of a weighted average of other OECD countries (i.e., the synthetic control group). In the years before the policy, the annual mean was 441.5 deaths per 100,000 people in Denmark and 442.7 in the synthetic control group. In the 3 years after the policy was implemented, mortality attributable to CVD decreased on average by about 14.2 deaths per 100,000 people per year in Denmark relative to the synthetic control group.

Conclusions: Denmark's food policy, which restricted the content of artificial trans fat in certain ingredients in its food supply, has been followed by a decrease in CVD mortality rates.
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Introduction

Cardiovascular disease (CVD) is a major cause of death in most Organisation for Economic Co-operation and Development (OECD) countries, accounting for about one third of all deaths in 2011.[1] Trans fat, which is present, notably, in partially hydrogenated oils (PHOs), has been found to be associated with CVD. Trans fat intake may affect cardiovascular health through several channels, including serum lipid levels, inflammation, and endothelial cell function. For example, the consumption of trans fat increases the ratio of low-density lipoprotein to high-density lipoprotein cholesterol, which increases the risk of developing coronary heart disease (CHD).[2–5] It has been estimated that the consumption of about 5 grams of trans fat per day is associated with a 25% increase in the risk of CHD.[6] The association between CVD and trans fat appears to be causal, but no RCTs with hard endpoints have been reported.[7]

Denmark responded to the adverse cardiovascular health effects of trans fat consumption by mandating that the content of artificial trans fat in oils and fats not exceed 2 grams per 100 grams of oil or fat.[8] Comparisons of food samples taken before and after the policy have shown reductions in trans fat content. It was possible to consume 30 grams of artificial trans fat in Denmark in 2001 "by eating two or three popular food products such as biscuits, microwave popcorn, chicken nuggets, and French fries," and the corresponding amount in 2005 was less than 1 gram.[9] The mean daily intake of artificial trans fat in Denmark was about 1 gram in 2001. The Danish Nutrition Council estimated that 1% of the Danish population or 50,000 people consumed more than 5 grams daily, which in part led the Danish government to

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regulate the content of artificial trans fat in certain ingredients in the food supply.[10]

In recent years, Denmark has seen a marked reduction in CVD mortality rates. Between 2003 and 2012, deaths attributable to CVD fell from 359.9 to 210.9 per 100,000 people, or from 34.6% to 25.1% as a percentage of all deaths (age-standardized rates are from OECD StatExtracts 2014, available at http://stats.oecd.org/). Many other OECD countries have also shown a declining trend in deaths attributable to CVD. The goal of this study was to assess whether some of the reduction in deaths caused by CVD in Denmark can be attributed to the implementation of the trans fat policy.

Methods

Data Sources and Exclusion Criteria

In our analysis, we used data from the OECD StatExtracts database, which provides comparable data for all OECD member states (http://stats.oecd.org/). The main variable of interest was the age-standardized CVD mortality rate per 100,000 people. Our sample started in 1990 and ended with the latest available year in 2012. This resulted in a balanced sample with 14 years prior to and 9 years after the policy was implemented in Denmark. Age-specific mortality rates were obtained from the WHO's Mortality Database (www.who.int/healthinfo/mortality_data/en/).

We also obtained country-level data on CVD risk factors (BMI, total cholesterol levels, and systolic blood pressure from WHO; fruit and vegetable consumption obtained from the Food and Agriculture Organization of the UN; and tobacco and alcohol consumption from OECD); economic conditions (health expenditures per capita, gross domestic product [GDP] per capita, and food price inflation defined as the percentage change over the previous year from OECD); and age structure (the percentage of the population aged >65 years from OECD). One caveat of our study is that there were no country-level data on potentially important covariates such as the use of statins and defibrillators.

Our original data set included information on all 34 OECD countries. Our goal was to estimate the impact of a national policy restricting the content of artificial trans fat in certain ingredients in the food supply, so we dropped from the sample countries that implemented other trans fat policies over the study period, such as trans fat labeling (Canada, Korea, and the U.S.) and voluntary self-regulation of trans fat content in food products in restaurants (Netherlands). Information on trans fat laws was obtained from the WHO (www.who.int/bulletin/volumes/91/4/12-111468/en/). We also dropped from the sample OECD countries that had an incomplete time series of CVD mortality rates over the study period.

We also excluded countries that implemented any policy regulating the content of artificial trans fat in food over the study period. Austria, Iceland, and Switzerland implemented laws between 2009 and 2011 similar to the Danish one. Denmark was the only case for which we had many years of pre- and post-policy data, both of which are important for synthetic control methods. And isolating the impact of a trans fat policy would have been difficult in some of the other cases because anti-smoking laws, which could have independent effects on CVD mortality rates, were implemented before their trans fat policy was implemented. Information on smoke-free laws was obtained from Americans for Nonsmokers' Rights (www.no-smoke.org/goingsmokefree.php?id=174). The analytic data set included information on Denmark and ten other OECD countries, which were used to form the synthetic control group for Denmark.

It is possible that there were spillovers resulting from Denmark's policy to other OECD countries resulting from shared transnational food supply chains, and some of these countries implemented anti-smoking laws over the study period (e.g., bans on smoking in public places). Both the spillovers and smoking laws in other OECD countries would, if anything, have worked against finding an effect of Denmark's trans fat policy on CVD mortality rates. Denmark implemented anti-smoking laws in August 2007. Fortunately, there was a post-policy period during which there were no national anti-smoking laws in place, allowing us to isolate the impact of the trans fat policy.

Statistical Analysis

Our empirical model compared Denmark's annual CVD mortality rates over time with those of a synthetic control group, which was composed of a weighted average of other OECD countries that did not implement a policy restricting the content of artificial trans fat in certain ingredients in food.[11] The weights assigned to control countries by the synthetic control estimator are non-negative, may range from zero to one, and sum to one. The estimator chose these weights in a recursive algorithm such that the synthetic Denmark most closely tracked the values of the pre-policy CVD mortality rates in Denmark. The synthetic control method's algorithm iterated through many combinations of weights until it found a single set of weights for the donor units that produced a control unit whose CVD path best approximated that of Denmark prior to the policy.

The variables used in the pre-policy matching process included CVD mortality rates (1990, 1995, 2000, and 2003) and the averages of all available information on the aforementioned CVD risk factors, health expenditures, age structure, food price inflation, and GDP. Measures of economic conditions were included because previous work indicates that they affect CVD mortality rates.[12,13] We found no evidence of abrupt changes in risk factor trends around the time of the policy using Chow tests. The model was implemented using the "synth" package in Stata, version 13.1.

The synthetic control approach offered a data-driven and objective way of choosing the control group. The use of a sample of disaggregated data and traditional methods of statistical inference would have captured uncertainty about the true aggregate values in the population. Here, the source of uncertainty was instead "the ability of the control group to reproduce the counterfactual outcome trajectory that the affected units would have experienced in the absence of the intervention."[11] The synthetic control method does not lend itself to classical methods of statistical inference, so we coupled the main analysis with placebo tests and permutation inference.

Results

In Panel A of Table 1, we show the weights that the synthetic control estimator assigned to each of the ten