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# Trans fat and cardiovascular disease mortality: Evidence from bans in restaurants in New York☆,☆☆

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ABSTRACT

This paper analyzes the impact of trans fat bans on cardiovascular disease (CVD) mortality rates. Several New York State jurisdictions have restricted the use of ingredients containing artificial trans fat in food service establishments. The resulting within-county variation over time and the differential timing of the policy's rollout is used in estimation. The results indicate that the policy caused a 4.5% reduction in CVD mortality rates, or 13 fewer CVD deaths per 100,000 persons per year. The averted deaths can be valued at about $3.9 million per 100,000 persons annually.



## 1. Introduction

The medical community has reached a consensus on the link between the consumption of trans fat and the risk of developing cardiovascular diseases (CVD) such as coronary heart disease (CHD). Previous work has estimated that a 2% increase in energy intake from trans fat increases the incidence of CHD by between 23% and 29% (Mozaffarian et al., 2006).[1] In November 2013, the American Medical Association (AMA) indicated that a substitution away from oils containing artificial trans fat toward healthier options such as extra virgin olive oil could prevent 30,000 to 100,000 premature deaths each year.[2] Danaei et al. (2009) estimate that high trans fat consumption is responsible for about 82,000 CVD-related deaths annually in the U.S. While the association between CVD and trans fat appears to be causal based on several plausible biological mechanisms, no randomized controlled trials (RCTs) with hard endpoints have been conducted (Brouwer et al., 2013).

In this paper, we contribute to the literature by investigating whether there is evidence in support of a causal effect of artificial trans fat consumption on CVD-related mortality. In particular, we evaluate a recent public policy response in some New York State (NYS) counties that mandated a substantial reduction in the

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[1] One gram of fat has 9 calories, so for an individual on a 2000-calorie daily diet this is approximately a 4.4 g increase in trans fat consumption.

[2] Visit the following link for the statement by Patrice A. Harris, MD, an AMA Board Member, "AMA: Trans Fat Ban Would Save Lives": http://www.ama-assn.org/ama/pub/news/news/2013/2013-11-07-trans-fat-ban-would-save-lives.page (accessed 30.05.14).

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amount of artificial trans fat in the local food supply.[3] The policy, which is commonly referred to as a "trans fat ban", applies to all food service establishments that require a permit to prepare and serve food. The regulation imposes an upper limit on the amount of artificial or industrially produced trans fat allowed in food, which is generally 0.5 g of trans fat per serving. Current estimates indicate that about one-third of daily calories come from food consumed outside the home (Lin and Guthrie, 2012), so this policy has far-reaching implications for nutrition and health.[4] Between 2007 and 2011, trans fat bans were implemented by the health departments of six NYS counties and New York City (NYC).

In our analysis, we use panel data on mortality rates from NYS counties for the 1999–2013 period.[5] These data allow us to employ an empirical approach that controls for statewide time-varying determinants of mortality and permanent differences across NYS counties. Trans fat bans and the resulting reductions in trans fat content in restaurant food were not randomly assigned across NYS counties. However, we make use of plausibly exogenous within-county variation over time in the artificial trans fat content in restaurant food resulting from the policy mandate and the differential timing of the policy's rollout to identify the CVD-related mortality effects of trans fat bans.

Our regression analysis indicates that mandating low upper limits on the content of artificial trans fat in restaurant food prevents a substantial number of CVD-related deaths. In particular, in our preferred specification, we find evidence indicating that the regulation caused, on average, a 4.5% reduction in CVD mortality rates per year, which translates into a reduction of about 13 CVD-related deaths per 100,000 persons per year. An analysis of the impacts on the major components of CVD mortality reveals that trans fat bans reduce mortality caused by heart disease by about 11 per 100,000 persons per year and reduce mortality due to stroke by about 2 per 100,000 persons per year.

Our results are robust to excluding NYC counties from the analysis, changes in the composition of the control group to address the potential for policy spillovers to neighboring counties and comparability concerns with treatment counties, a variety of changes in model specification, and addressing policy endogeneity concerns (e.g. menu labeling laws and hospital-level interventions in NYC counties to increase the accuracy of cause-of-death reporting). Placebo analyses indicate that trans fat bans have much weaker impacts on mortality outcomes that are less likely or unlikely to be associated with the consumption of artificial trans fat.

A dynamic analysis reveals that CVD-related mortality responds within 1 year after the regulation reduced the amount of artificial trans fat in the local food supply. This is consistent with evidence from diet-related RCTs in the medical literature.[6] For instance, the incidence of CVD-related fatal and non-fatal events falls within 1 year after individuals at high CVD risk switch to a Mediterranean diet and consume healthier fats (Estruch et al., 2013).[7,8] Dietary RCTs assessing brief periods (17–70 days) of trans fat consumption have shown that substituting trans fat with healthier fats decreased low-density lipoprotein (LDL) cholesterol levels (Mozaffarian and Clarke, 2009),[9] and a 16-week RCT that randomized receipt of oil containing industrially produced trans fat (Bendsen et al., 2011) found that trans fat consumption increased biomarkers of systemic inflammation. There is also evidence that the rate at which the heart beats increases within a couple of months after increasing the intake of trans fat (Dyerberg et al., 2004), which results in an increased risk of CVD mortality.[10] Controlled feeding studies with animals find that a diet rich in trans fat promotes pro-inflammatory responses and vascular dysfunction, which substantially increases the risk of sudden cardiac death within a few months.[11] Interestingly, our dynamic analysis reveals that the mortality response to the implementation of trans fat bans is faster for heart disease than it is for stroke. Evidence from the medical literature that trans fat consumption has a pro-arrhythmic effect on the human heart (Soares-Miranda et al., 2012) may be the underlying biological explanation.

Heart disease is the leading cause of death in NYS, and we find that trans fat bans have the potential to lead to substantial reductions in the loss of life resulting from the consumption of artificial trans fat, which has no known health benefits. Given that the NYS counties that implemented trans fat bans over our study period had 34,215 heart-disease-related deaths in 2006, we estimate that, on average, implementation of trans fat bans prevented about 1540 heart-disease-related deaths per year. Assuming a discount rate of 3%, Aldy and Viscus (2008) find that the cohort-adjusted Value of a Statistical Life-Year is about $302,000. Even if fatal heart attacks cause only 1 year of life to be lost, the fatal heart attacks prevented by trans fat bans can be valued at about $465 million annually.

The rest of the paper is organized as follows. First, we describe the data used in the analysis. Second, we examine raw trends in

[3] In 2003, the U.S. FDA mandated that trans fat content be listed on the Nutrition Facts panel of packaged foods by 2006. The food industry reacted by reformulating its products to reduce the amount of trans fat contained in packaged foods (Unnevehr and Jagmanaite, 2008), and recent work has documented a marked reduction in the amount of trans fat in the American diet (Doell et al., 2012): between 2000 and 2009, trans fat levels in the blood of non-Hispanic white adults decreased by 50% (Vesper et al., 2012). However, foods prepared outside of the home were not affected by mandatory trans fat labeling requirements.

[4] In 2005–2008, about 20% of daily calories were consumed at restaurants and fast food outlets and 12% of daily calories were consumed at other establishments away from home (Lin and Guthrie, 2012). Because most of the calories consumed away from home are from restaurants and fast food outlets, we often use the term "restaurants" to refer to the establishments targeted by the policy for ease of exposition.

[5] In a supplementary analysis, we also use panel data on mortality rates from large counties in metropolitan statistical areas with one million or more population, which include counties both inside and outside NYS.

[6] Our results are also consistent with evidence in the economics literature that cardiovascular health is sensitive to changes in the environment or health behavior. For example, there is evidence that CVD-related mortality falls shortly after increases in cigarette taxes (Moore, 1996), the implementation of smoke-free workplace laws (Adams et al., 2013), changes in macroeconomic conditions (Ruhm, 2003), and income receipt (Evans and Moore, 2011, 2012).

[7] In a large RCT in Spain, individuals with high CVD risk, but no CVD at baseline, were randomly assigned to be either (a) counseled to follow a Mediterranean diet and given extra-virgin olive oil or a mixture of nuts for free on a weekly basis, or (b) advised to reduce fat intake. The study found that there were fewer CVD-related events (including deaths) within 1 year after an increased consumption of healthier fats (Estruch et al., 2013).

[8] In a letter to the editor in response to this study, a prominent medical researcher in the field, Dariush Mozaffarian, indicated that "[f]ewer cardiovascular events were apparent within 1 year, which is consistent with rapid changes in risk factors when dietary quality is altered in controlled feeding studies and in populations when nutrition trends shift" (see http://www.nejm.org/doi/full/10.1056/NEJMc1306659, accessed 21.07.15).

[9] Law et al. (2003) found that RCTs aimed at reducing LDL cholesterol levels using methods such as statin therapy and dietary change resulted in decreases in fatal and non-fatal heart disease events in the 1st year in trial.

[10] Dyerberg et al. (2004) randomly assigned healthy males to an 8-week diet enriched in trans fatty acids (TFA) and, in a subgroup analysis of men with normal heart rate variability at baseline, TFA increased 24-hour heart rate by an average of 3 beats per minute. There is work linking CVD mortality with increases in heart rate (see Kannel et al., 1987; Greenland et al., 1999; Reunanen et al., 2000 – as quoted in Dyerberg et al., 2004).

[11] Siddiqui et al. (2009) conducted an RCT using mice and rats. The animals were first induced to have a myocardial infarction and were then randomly allocated to be fed a diet rich in TFA or a control diet. The authors report that "it is evident from 6-month survival data that only 50% of the animals survived on a TFA-enriched diet" while "[s]ixty-five percentage of the animals (control) survived consuming a diet closely resembling a typical Western diet." The authors reported that the effects of TFAs "primarily affect[ed] arrhythmia generation (i.e. sudden death)" and sudden cardiac death differences emerged because a TFA-enriched diet promotes pro-inflammatory responses and vascular dysfunction.