Michal Schapira

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Does Eating a Meal Away from Home Have a Causal Effect on its Sodium Content?

**Introduction**

The World Health Organization (WHO) asserts in a 2007 technical report that “many lines of investigation…have provided evidence for a causal relationship between salt intake and cardiovascular disease.” Ischemic heart disease is the #1 cause of death for both high-income and low-income countries (Lopez et al 2006), and the vascular plaque build-up that can be brought on by high salt intake can also cause stroke, the #2 cause of death for both high-income and low-income countries (Lopez et al 2006), as well.

That high salt intake (in this paper, “salt intake” will be used interchangeably with “sodium intake”) leads to disease, then, is well-established, but what interventions will actually reduce salt intake in the general population? This question can only be answered by a statistically sound investigation into the *causal* factors driving salt intake. Folk wisdom suggests that people eat more salt at restaurants than they would at home, because the food at restaurants is laden with far more salt than the restaurant-goer would use to season his or her food at home. However, perhaps restaurant-goers who consume high amounts of salt also consume high amounts of salt at home? A 2003 study by Paeratakul et al corroborated the observation that both adults and children who reported eating at a fast-food restaurant on a given day consumed more sodium that day than those who did not; additionally, since the study involved 2 non-consecutive days for which food intake the previous day was reported within individuals, it was also able to show that individuals who “ate out” on one day but not the other had a higher sodium intake on the day that included the meal at the fast-food establishment. However, the statistical methods used in the paper were limited to weighted comparison of mean intakes and pairwise t-tests, and the study itself clearly states that its “study design does not provide evidence of the causal relationship between fast-food consumption and diet quality.” To establish and approximate a *causal* relationship between eating a meal away from home and that meal having a higher sodium content than the meal one would otherwise eat at home, more advanced statistical methods must be used.

This study seeks to define the causal relationship between meal location (home vs away from home – it was not possible to determine exactly where a meal was eaten) and sodium content using the difference-in-difference (DiD) method and investigating whether this relationship is affected by two possible confounding variables: (1) *day type:* whether the meal was consumed on a weekend vs weekday, and (2) *meal source:* whether the meal primarily consisted of premade food or was primarily prepared by the consumer. In other words, we are not asking whether meals prepared from scratch are healthier than fast food: that much is obvious (although we will confirm it). Instead, we are also asking if people consume less sodium when they are eating premade food (e.g. frozen pizza) or takeout food at home, compared to eating at restaurants. If this would be the case, one can envision a public-health campaign encouraging consumers that they don’t have to expend effort cooking; rather, they should simply try to eat at home rather than away from home. We are also asking if this effect is different in magnitude or direction on the weekends vs weekdays, because of cultural norms surrounding less healthy eating habits on weekends.

**Methods: Data Collection**

Since the early 1960’s, the National Center for Health Statistics (a division of the Centers for Disease Control and Prevention) has conducted the National Health and Nutrition Examination Survey (NHANES), providing linked but de-identified demographic, laboratory, and interview-based dietary and health-related data for over 5,000 Americans in a weighted population-based sample each year. This analysis utilized the dietary data from NHANES 2015-2016, for a total of approximately 10,000 civilian, non-institutionalized subjects.

The dietary recall interviews were conducted in NHANES mobile examination centers, with the aid of booklets and actual measuring tools. Interviewers asked subjects systematically, with multiple passes, about the food they had consumed during the previous 24 hours, where they had obtained it, where they had consumed it, and how much they had consumed. For example, if a subject reported that he or she had consumed a bowl of cereal, the subject would be asked to look at a picture of different bowls in a booklet that was marked with horizontal lines along the outer surface of the bowl and asked which bowl approximately matched the size of the bowl they used and to which of the lines they had filled it. This survey was repeated 3-10 days later with each subject on a different day of the week, via phone (the measuring tools were mailed to the subjects). The NHANES staff then assigned a code to each food (8,690 codes to cover the 121,000 foods reported in the study) and computed nutritional information for each food according to its code using USDA's Food and Nutrient Database for Dietary Studies 2015-2016.

Five variables from this dataset were utilized for each food: *meal type* (breakfast, lunch, dinner or supper)*, meal source* (grocery store, fast-food restaurant, restaurant with a waiter/waitress, or convenience store)*, day of week*, *meal location* (at home or away from home), and food code.

**Methods: Data Analysis**

For the purposes of this study, a “premade food” is defined as a food that met either of the following criteria:

1. Its *meal source* variable indicated that it was obtained from a convenience store, fast-food restaurant, or restaurant with a waiter/waitress
2. The *code* variable description contained the words “from frozen,” “prepackaged mix,” “ready-to-heat,” or “luncheon meat.” Frozen vegetables and dessert items, however, despite containing the words “from frozen” in their descriptions, were not counted as premade because they were considered to be side dishes rather than primary meal components (see below). Foods that were considered premade under this criterion included frozen pizza, frozen waffles, macaroni and cheese from prepared mixes and ready-to-heat pasta dishes.

For all experiments, comparisons were only made across meals eaten by the same individual which had the same *meal type* variable – in other words, a dinner eaten by Person A on Day 1 of the study was only considered if data was available for the dinner eaten by Person A on Day 2. Thus, sodium content was aggregated by meal and therefore a “premade” status had to be assigned to the whole meal. Any meal with at least one premade ingredient was considered to be entirely premade, which is why care was taken to only include main-dish-style foods in the above list of items that could be considered premade even if they were obtained from a grocery store.

To illustrate, 5 rows from the master dataset are shown below:



The statistical methodology used was a modified differences-in-differences (DiD) technique; whereas a traditional DiD has two classes, untreated and treated, ours has 4: (1) first-day meal eaten at home and second-day meal eaten away from home (H1A2), (2) first-day meal eaten away from home and second-day meal eaten at home, (A1H2) (3) both meals eaten at home (H1H2), and (4) both meals eaten away from home (A1A2). Thus, the DiD was performed as follows for each dataset (subscripts indicate the first-day meal or the second-day meal for a particular class)

1. Consider “home” as the untreated state and “away” as the treated state. Take as the “untreated” difference and as the “treated” difference and calculate

This serves to separate the variation (i.e. change in sodium content) that is a result of having the second-day meal away from home from the variation that would have occurred even if one had eaten the second-day meal at home – the “background noise.” We term this the “regular DiD.”

1. Consider “away” as the untreated state and “home” as the treated state. Take as the “untreated” difference and as the “treated” difference and calculate

This serves to separate the variation that is a result of having the second-day meal at home from the variation that would have occurred even if one had eaten the second-day meal away from home – the “background noise.” We term this the “reverse DiD.”

For consistency, in both cases the sodium content of the “home” meal is subtracted from the sodium content of the “away” meal when the meals were eaten in different locations, and the subtraction order of the same-location meals follow their cases. To illustrate:

H1H22 – H1H21

H1H22 – H1H21

(H1A22 – H1A21)

- (H1H22 – H1H21)

Time

H1A2 (treated)

H1H2 (untreated)

H1A2, if untreated

H1A22 – H1A21

Sodium content

Figure 1. Regular DiD. The untreated diff is given in red, the treated diff is given in blue, and the treated diff minus the untreated diff (in other words, the treatment effect) is given in purple.

A1A21 – A1A22

(A1H21 – A1H22)

- (A1A21 – A1A22)

Time

A1H2 (treated)

A1A2 (untreated)

A1H2, if untreated

A1H21 – A1H22

A1A21 – A1A22

Sodium content

Figure 2. Reverse DiD. The untreated diff is given in red, the treated diff is given in blue, and the treated diff minus the untreated diff (in other words, the treatment effect) is given in purple.

For each set of conditions investigated, equal numbers of samples were used for each of the cases; that is, n(A1A2) = n(A1H2) and n(H1H2) = n(H1A2), so that the “treated” group (A1H2 and H1A2) would be the same size as the “untreated” group (A1A2 and H1H2), to minimize differences in variance between the groups. The difference in sodium content between the “treated” and “untreated” groups was calculated using Welch’s two-sample unpaired t-test. All analysis was performed using R.

**Results**

The treatment diffs and their p-values for each set of conditions are shown in the table below.

|  |  |  |  |
| --- | --- | --- | --- |
| Premade? | Day type | (sodium in the “away meal”)  - (sodium in the “home meal”) | p-value |
| Either | Either | +97.8mg | 0.0018\*\* |
| Either | Weekday | +169.2mg | 0.00021\*\*\* |
| Either | Weekend | -318.7mg | 0.059**.** |
| Premade | Either | +20.7mg | 0.76 |
| Not premade | Either | -132.6mg | 0.0098\*\* |
| Premade | Weekday | +104.5mg | 0.35 |
| Not premade | Weekday | -61.8mg | 0.38 |
| Premade | Weekend | -52.9mg | 0.87 |
| Not premade | Weekend | -644.1mg | 0.050**.** |

p < 0.001: \*\*\*, p < 0.01: \*\*, p < 0.05: \*, p < 0.1: **.**

**Discussion**

The results demonstrate that meals eaten at home had a lower sodium content than those eaten away from home overall, with a more pronounced effect on weekdays and surprisingly, a somewhat significant effect in the opposite direction on weekends. However, when the premade status of the meal was accounted for, an effect could only be seen in the non-premade-meals group, not in the premade-meals group, and it was a negative effect. When meals were matched both on day type and premade statuses, the sample sizes became too small to produce statistically significant effects, although a somewhat significant negative effect of eating away from home is seen for non-premade meals on weekends.

This unfortunately indicates that the answer to our main question, whether less sodium is likely to be consumed at a meal consisting primarily of premade food if one eats it at home vs away from home, is inconclusive. However, we can conclude that the meals eaten at home on weekdays tend to have *less* sodium than meals eaten away from home, whereas meals eaten at home on weekends, as well as meals eaten at home that are not premade, tend to have *more* sodium than their counterpart meals eaten away from home. This is a surprising finding that merits further study. Perhaps public health campaigns aimed at reducing sodium intake should focus on long Sunday brunches which encourage large portions, even though the food may be homemade, in addition to weeknight dinners in which the desire for healthy eating gives way to the convenience of McDonald’s.

However, it must be noted that the only effects of day type and meal source studied here are their *interactions* with the effect of meal location on sodium content; the effects of day type and meal source directly on sodium content were not studied.

**Conclusion**

While meals eaten at home had a lower content than meals eaten away from home overall, this effect was reversed for non-premade meals as well as meals eaten on weekends. The results were inconclusive when only premade food was studied.

Recommended future work includes studying this effect on NHANES data from other years and/or pooling it with the 2015-2016 data in order to obtain greater sample sizes. Additionally, although demographic data was not necessary for this study because the “away meal” and “home meal” were eaten by the same person in each case, it would be interesting to study whether the effect of eating at home vs. away differed for people of various ethnicities, genders, incomes, education levels, or body-mass indices (BMI’s). All of this data is also collected for each participant in NHANES.