# Grocery Bag Bans and Foodborne Illness

**Jonathan Klick**

**Joshua D. Wright**[♦]

**November 2, 2012**

## Abstract

Recently, many jurisdictions have implemented bans or imposed taxes upon plastic grocery bags on environmental grounds. San Francisco County was the first major US jurisdiction to enact such a regulation, implementing a ban in 2007. There is evidence, however, that reusable grocery bags, a common substitute for plastic bags, contain potentially harmful bacteria. We examine emergency room admissions related to these bacteria in the wake of the San Francisco ban. We find that ER visits spiked when the ban went into effect. Relative to other counties, ER admissions increase by at least one fourth, and deaths exhibit a similar increase.

♦ Klick (jklick@law.upenn.edu), Professor of Law, University of Pennsylvania and Erasmus Chair of Empirical Legal Studies, Erasmus University Rotterdam; Wright (jwrightg@gmu.edu), Professor, George Mason University School of Law and Department of Economics. We thank Nathan Harris, Natalie Hayes, and Elise Nelson for excellent research assistance. Klick thanks the Property and Environment Research Center (PERC) for support for this project through its Julian Simon Fellowship.

## Introduction

In an effort to reduce litter and protect marine animals, jurisdictions across the globe are considering banning plastic grocery bags. In the US, California leads the way. San Francisco enacted a county-wide ban covering large grocery stores and drug stores in 2007. It extended this ban to all retail establishments in early 2012. Los Angeles followed suit in 2012, as did a number of smaller cities throughout the state. Some municipalities have imposed taxes on the bags rather than implement direct bans.

These bans are designed to induce individuals to use reusable grocery bags, in the hope that a reduction in the use of plastic bags will lead to less litter. Recent studies, however, suggest that reusable grocery bags harbor harmful bacteria, the most important of which is E. coli. If individuals fail to clean their reusable bags, these bacteria may lead to contamination of the food transported in the bags. Such contamination has the potential to lead to health problems and even death.

We examine the pattern of emergency room admissions related to bacterial intestinal infections, especially those related to E. coli around the implementation of the San Francisco County ban in October 2007. We find that ER admissions increase by at least one fourth relative to other California counties. Subsequent bans in other California municipalities resulted in similar increases. An examination of deaths related to intestinal infections shows a comparable increase.

Using standard estimates of the statistical value of life, we show that the health costs associated with the San Francisco ban swamp any budgetary savings from reduced litter. This assessment is unlikely to be reversed even if fairly liberal estimates of the other environmental benefits are included.

We provide details about the motivation for and the provisions of the San Francisco ban in Section 2. We discuss the evidence regarding the health risks of reusable bags in Section 3. Section 4 provides our estimates of the effect of the San Francisco ban, and Section 5 provides a cost benefit analysis. Section 6 concludes.

## 2. Grocery Bag Bans

In 2007,[1] San Francisco adopted the Plastic Bag Reduction Ordinance ("PBRO") prohibiting the distribution of non-compostable plastic checkout bags by supermarkets with more than $2 million in annual gross sales and by pharmacies with at least five locations within San Francisco. The PBRO amended the San Francisco Environmental Code to require the affected stores to distribute only compostable plastic, recyclable paper, or reusable bags at checkout.

The PBRO cites as the motivation for the law San Francisco County's duty to reduce the environmental impact of plastic checkout bags both locally and more broadly. The ordinance attributes the deaths of over 100,000 marine animals per year to plastic entanglement and states that over 12 million barrels of oil are required to produce the plastic bags used in the United States annually. The PBRO favorably references a bag tax in Ireland, and claims the Irish ordinance led to a 90 percent reduction in plastic checkout bag usage.

In addition to prohibiting the distribution of non-compostable plastic checkout bags, the PBRO regulates the distribution of compostable plastic bags, recyclable paper bags, and reusable bags. The PBRO provides that a compostable plastic bag must meet the American Society for Testing and Materials's standards for compostability by a recognized verification entity, and must display the terms "Green Cart Compostable" and "Reusable" in a highly visible manner on the outside of the bag. The PBRO further provides that any recyclable paper bag distributed by a covered store at a checkout must contain no old growth fiber, be 100 percent recyclable, contain at least 40 percent post-consumer recycled content, and display "recyclable" and "reusable" in a highly visible manner on the outside of the bag. The PBRO also requires that reusable bags be made of cloth or other machine washable fabric, or made of durable plastic at least 2.25 mils thick.

Violation of the PBRO results in fines of up to $100 for the first violation, $200 for the second violation, and $500 for each subsequent violation in a given year. The ordinance also

[1] The ban was adopted on April 20, 2007, and went into effect on October 20, 2007.

contemplates city administrators within the county imposing administrative penalties equal to the fines. The City Attorney may seek injunctive relief or civil penalties of up to $200 for the first violation, $400 for the second violation, and $600 for each subsequent violation in a given year.

In February 2012, the San Francisco Board of Supervisors expanded the non-compostable plastic checkout bag ban to cover all retail and food establishments in San Francisco County. Effective October 1, 2012, stores must charge a minimum of $0.10 for any bag provided to customers. The stores must list the bag charge separately on each customer's receipt. The mandatory $0.10 charge does not apply to transactions paid for via food stamps or other government aid programs.

The expanded ordinance also details additional requirements for bags to be designated as "reusable." As of October 1, 2012, reusable bags must have a usable life greater than 125 uses, and be capable of carrying at least 22 pounds over a distance of at least 175 feet. Furthermore, reusable bags must be durable enough to be washed and disinfected at least 100 times. Because the usable life requirement exceeds the number of washes requirement, the ordinance assumes the bag will not be washed after every use.

Several other California municipalities banned plastic bags in the two years after the San Francisco ban,[2] including the City of Malibu, the Town of Fairfax, and the City of Palo Alto.

Malibu's ordinance prohibits retail establishments (including grocery stores, pharmacies, liquor stores, convenience stores, and any store selling food, clothing, or personal items) from providing any plastic checkout bags (regardless of compostability) to a customer. Stores may provide recyclable paper bags, as well as single item plastic bags. The ordinance does not include any stipulated penalties.

In the Town of Fairfax, the plastic bag ordinance provides that all retail establishments may distribute only recyclable paper bags or reusable bags. The penalties for distributing a prohibited

[2] California law prohibits municipalities from instituting taxes or fees on plastic bags until at least 2013, which has resulted in local governments seeking to regulate plastic bag distribution implementing bans rather than taxes.

bag is up to $100 for the first offense, $200 for a second offense, and $500 for each subsequent offense in a given year.

Palo Alto's plastic bag ordinance prohibits supermarkets with at least $2 million in annual gross revenue from distributing anything other than recyclable paper bags or reusable bags. Violators are subject to a penalty not greater than $250 for the first two offenses. Three or more violations constitute a misdemeanor, which allows for fines up to $1,000. Table 1 lists the grocery bag bans in California.[3]

| Table 1: Grocery Bag Bans in California | |
|---|---|
| Jurisdiction | Implementation Date |
| San Francisco (county and city) | October 20, 2007 |
| Malibu (city) | November 26, 2008 |
| Fairfax (city) | June 4, 2009 |
| Palo Alto (city) | September 18, 2009 |

Each jurisdiction banning the use of plastic bags has done so with the express or implied purpose of promoting the use of reusable bags. The Palo Alto Council explained that its intent was to "encourage[] the use of reusable bags" (Palo Alto 2009). The Town of Fairfax also cited the State Legislature's intent to encourage the use of reusable bags as part of the reason why it needed to adopt its ordinance (Town of Fairfax 2008). San Francisco's ban required the use of paper bags, compostable plastic bags, or reusable bags (San Francisco 2007). Though reusable bags are one of three allowed options, the high cost of paper bags (6.8 times more expensive than normal plastic bags) and compostable plastic bags (2 to 10 times more expensive than normal plastic bags) makes reusable bags the most viable option (Nashville Wraps 2008; d2w Inside

[3] Other California cities which have adopted bans include: Santa Monica, Calabasas, Long Beach, San Jose, Manhattan Beach, Pasadena, Monterey, Sunnyvale, Ojai, Millbrae, Laguna Beach, Los Angeles, Dana Point, Carpinteria, Ukiah, Watsonville, Solana Beach, Fort Bragg, Carmel-by-the-Sea, Santa Cruz. Other California counties include: Los Angeles (unincorporated areas), Santa Clara, Marin, Santa Cruz, San Luis Obispo, Alameda, Mendocino (unincorporated areas). Sixteen jurisdictions outside California have adopted laws banning or taxing plastic bags.

2010; Oxo-biodegradable Plastics Association 2011; Chou and Garg 2010). Thus, the San Francisco likely increased the use of reusable bags.

There is some evidence plastic bag bans and attempts to encourage reusable bag use have been successful. There was an 18 percent decrease in plastic bag litter in San Francisco two years after the ban was implemented (City of San Francisco 2009). The Los Angeles Public Works Department documented a 95 percent decrease in plastic bag use (Los Angeles Department of Public Works 2012) soon after its ban took effect. Furthermore, the California Grocers Association found that 90 percent of their San Francisco customers were bringing their own reusable bags (Finz 2012).

## 3. What's In Your Bag?

Williams et al (2011) randomly selected reusable grocery bags from consumers in grocery stores in Arizona and California. They examined the bags, finding coliform bacteria in 51 percent of the bags tested. Coliform bacteria were more prevalent in the California bags, especially those collected in the Los Angeles area. E. coli was found in 8 percent of the bags examined. The study also found that most people did not use separate bags for meats and vegetables. Further, 97 percent of individuals indicated they never washed their reusable grocery bags. Bacteria appeared to grow at a faster rate if the bags were stored in car trunks. This study suggests there may be large risks associated with using reusable grocery bags, though it does imply that fastidiously washing bags can virtually eliminate the risks. However, the survey results suggest that virtually no one washes these bags.

This study highlights the risk of cross contamination involved with the use of these bags and the general tendency of their users not to clean them. Thus, it is possible that banning plastic grocery bags can lead to public health problems, as individuals substitute to reusable bags.

## 4. Plastic Bag Bans and Bacterial Infections

We focus on the San Francisco ban because it is the earliest ban in a major U.S. jurisdiction, allowing us to examine the longest post ban time series. To analyze emergency room visits, we used the California Office of Statewide Health Planning and Development's Emergency Department and Ambulatory Surgery Data for each quarter from 2005-2010. These data provide the county of residence of each person admitted to a California ER, as well as the principal diagnosis for the individual using ICD-9 codes. Given the prevalence of coliform bacteria, especially E. coli, in reusable grocery bags, we focus on ER visits involving E. coli. Jin and Leslie (2003) used a similar method to determine how "hygiene improvements by restaurants" affected hospital admissions for food borne illnesses. In subsequent analyses, we examine other bacterial infections, including salmonella, campylobacter, and toxoplasmosis. Together, the CDC reports, these and E. coli account for 62 percent of all hospitalizations related to foodborne illnesses.[4]

We also examine annual death aggregated at the county level. We examine cause of death data from the CDC Wonder System. Given the confidentiality protocols of this data source, we are not able to examine all counties in California since county periods with few deaths attributable to a given cause of death are censored. To maximize our sample, we aggregate over all ICD-10 codes comprising "intestinal infectious diseases" (A00-A09).

Descriptive statistics are available in Table 2.

[4] http://www.cdc.gov/foodborneburden/2011-foodborne-estimates.html/. Another 26 percent are accounted for by norovirus infections.

| Table 2: Descriptive Statistics | | | | |
|---|---|---|---|---|
| Variable | Definition | Mean | Std. Dev. | Source |
| ER Visits for E. Coli | Number of emergency room admissions in given county in given quarter of a year where principal diagnosis code involved E. coli | 84 | 179 | California Office of Statewide Health Planning and Development |
| ER Visits for Salmonella | Number of emergency room admissions in given county in given quarter of a year where principal diagnosis code involved salmonella. | 0.43 | 1.03 | California Office of Statewide Health Planning and Development |
| ER Visits for Campylobacter | Number of emergency room admissions in given county in given quarter of a year where principal diagnosis code involved campylobacter. | 0.33 | 0.81 | California Office of Statewide Health Planning and Development |
| ER Visits for Toxoplasmosis | Number of emergency room admissions in given county in given quarter of a year where principal diagnosis code involved toxoplasmosis. | 0.05 | 0.27 | California Office of Statewide Health Planning and Development |
| Deaths from intestinal diseases | Number of deaths in given county in given year attributed to causes listed under the ICD-10 heading “intestinal infectious diseases” (A00-A09). | 123 | 186 | CDC |

### 4.a ER Visits and the Bag Ban

We examine admissions to California emergency rooms. ER data are aggregated at the quarterly level, allowing us to precisely isolate the relationship between any change in health outcome and the implementation of the San Francisco ban in the fourth quarter of 2007.

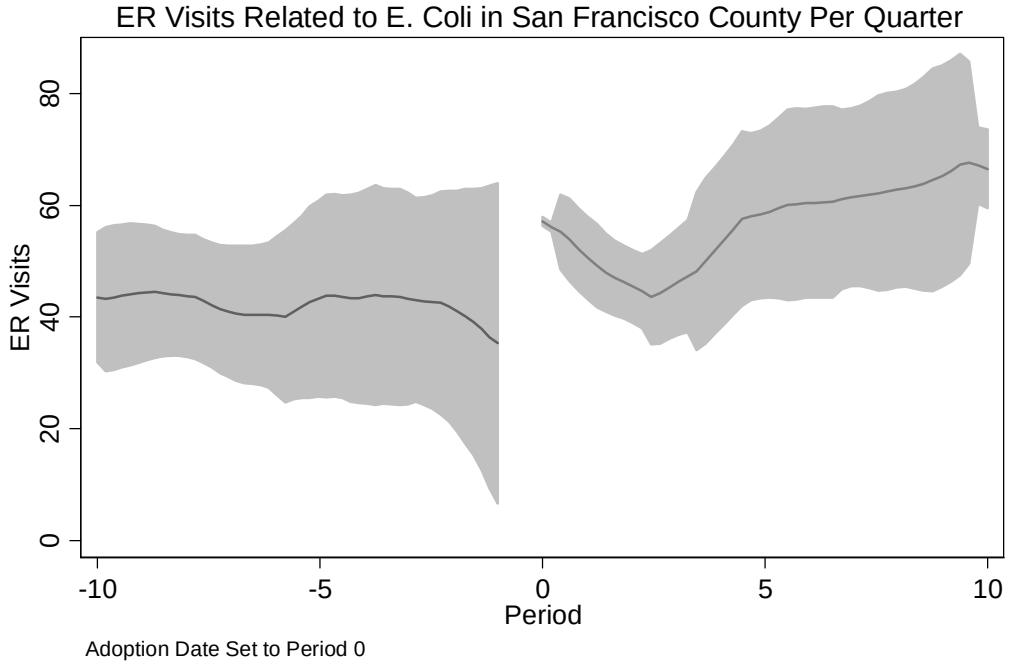
We aggregated the ER data by county of the patient's residence and quarter of year, counting all the instances where the patient's principal diagnosis involved E. coli according to the recorded ICD-9 code. The data allow us to examine every quarter from the beginning of 2005 through the end of 2010. We examine the natural log of the number of ER visits involving E. coli, controlling for county fixed effects and separate time fixed effects for each quarter. We cluster the standard errors at the county level to account for dependence over time within a county.[5]

In the analysis of San Francisco County, we omit data for other counties when they too later pass plastic bag bans. Since the subsequent bans in the sample period involved sub-county level municipalities (Malibu in Los Angeles County, Fairfax in Marin County, and Palo Alto in Santa Clara County), these bans are not directly comparable to the San Francisco County ban. We do, however, examine the effects of these subsequent bans later in the article.

Figure 1 provides a local polynomial smoothed regression of the number of ER visits in San Francisco County allowing for a discontinuity between the third and the fourth quarters of 2007 when the bag ban was implemented. The quarter of adoption is set to 0 in the figure, and 10 periods before and after implementation are included, as well as the 95 percent confidence intervals.

[5] If we account for multi-dimensional clustering by county and time period as described in Cameron, Gelbach, and Miller (2011), as might be appropriate if, for example, counties experience effects from changes in food supply chains at the same time, the conclusions are not affected.

Figure 1:




There is a clear discontinuity at the time of adoption. Figure 2 illustrates that the rest of the Bay Area counties do not show the same discontinuity.

Figure 2:

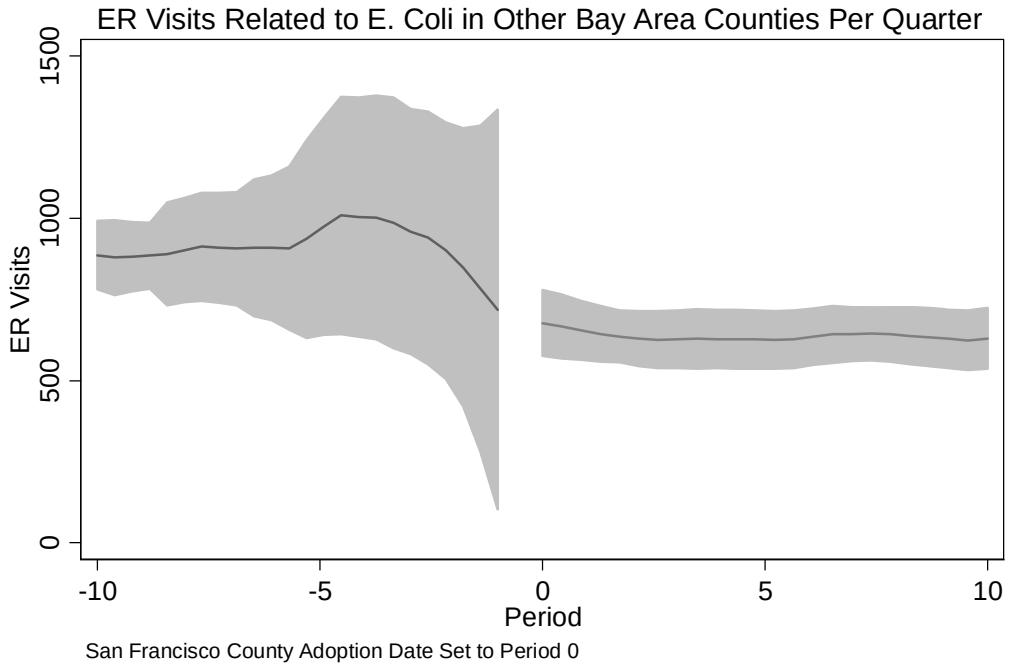



Table 3 provides the regression results using all California counties and then restricting the sample to just the Bay Area counties. In addition to county and period fixed effects, some of the specifications include county-specific linear trends.

| Table 3 | | | | |
|---|---|---|---|---|
| Effect of San Francisco Plastic Bag Ban on ER Admissions for E. Coli | | | | |
| (standard errors clustered at county level) | | | | |
| | All CA Counties | | Bay Area Counties Only | |
| Bag Ban | 0.27***<br>(0.06) | 0.52***<br>(0.07) | 0.43***<br>(0.11) | 0.68***<br>(0.12) |
| County FEs | Yes | Yes | Yes | Yes |
| Period FEs | Yes | Yes | Yes | Yes |
| County Trends | No | Yes | No | Yes |
| Relative Effect | +32% | +68% | +53% | +97% |
| Observations | 1,130 | 1,130 | 203 | 203 |

Note: Dependent variable is the natural log of the number of emergency room visits in given county in a given quarter where the principal diagnosis code involved E. coli. Data is omitted for quarters in which other counties contained a jurisdiction where a bag ban was in effect, specifically Los Angeles County starting in the 4th quarter of 2008 (due to a ban in Malibu), Marin County starting in the 2nd quarter of 2009 (due to a ban in Fairfax), and Santa Clara County starting in the 3rd quarter of 2009 (due to a ban in Palo Alto).

*** $p < 0.01$ (against a two-sided test of a null hypothesis of the bag ban coefficient = 0)

** $p < 0.05$ (against a two-sided test of a null hypothesis of the bag ban coefficient = 0)

* $p < 0.10$ (against a two-sided test of a null hypothesis of the bag ban coefficient = 0)

Regardless of the sample, the San Francisco County ban is associated with a statistically significant and particularly large increase in ER visits for E. Coli infections. We find increases between one fourth and two thirds, suggesting an increase in visits between 72 and 191 annually.

In Table 4, we end the sample in the 4th quarter of 2007 to isolate the immediate effect of the San Francisco County ban.

| Table 4 | | | | |
|---|---|---|---|---|
| Immediate Effect of San Francisco Plastic Bag Ban on ER Admissions for E. Coli | | | | |
| (standard errors clustered at county level) | | | | |
| | All CA Counties | | Bay Area Counties Only | |
| Bag Ban | 0.41***<br>(0.08) | 0.81***<br>(0.09) | 0.66***<br>(0.14) | 0.87***<br>(0.12) |
| County FEs | Yes | Yes | Yes | Yes |
| Period FEs | Yes | Yes | Yes | Yes |
| County Trends | No | Yes | No | Yes |
| Relative Effect | +51% | +124% | +94% | +139% |
| Observations | 574 | 574 | 108 | 108 |

Note: Dependent variable is the natural log of the number of emergency room visits in given county in a given quarter where the principal diagnosis code involved E. coli. Data is omitted for quarters beyond the 4th quarter of 2007 when San Francisco implemented its ban.

*** $p < 0.01$ (against a two-sided test of a null hypothesis of the bag ban coefficient = 0)

** $p < 0.05$ (against a two-sided test of a null hypothesis of the bag ban coefficient = 0)

* $p < 0.10$ (against a two-sided test of a null hypothesis of the bag ban coefficient = 0)

When we restrict attention to the first quarter the San Francisco ban was in place, the magnitude of our results is even larger. This suggests that the ban led to an increase in infections immediately upon implementation.

Table 5 provides results examining the other California bans as well. We present results both with and without San Francisco County included. For the sub-county bans (i.e., all of the examined bans except San Francisco), we coded all individuals from a county in which an individual jurisdiction adopted a ban as affected by the ban. This is surely too broad. However, because it is likely that individuals sometimes shop in other municipalities than those in which they reside, we decided on this approach as being the most conservative.

| Table 5 | | | | |
|---|---|---|---|---|
| Effect of all California Plastic Bag Bans on ER Admissions for E. Coli | | | | |
| (standard errors clustered at county level) | | | | |
| | San Francisco County Included | | San Francisco County Excluded | |
| Bag Ban | 0.18***<br>(0.06) | 0.25***<br>(0.09) | 0.15**<br>(0.06) | 0.20**<br>(0.10) |
| County FEs | Yes | Yes | Yes | Yes |
| Period FEs | Yes | Yes | Yes | Yes |
| County Trends | No | Yes | No | Yes |
| Relative Effect | +20% | +29% | +16% | +22% |
| Observations | 1,152 | 1,152 | 1,128 | 1,128 |

Note: Dependent variable is the natural log of the number of emergency room visits in given county in a given quarter where the principal diagnosis code involved E. coli.

*** $p < 0.01$ (against a two-sided test of a null hypothesis of the bag ban coefficient = 0)

** $p < 0.05$ (against a two-sided test of a null hypothesis of the bag ban coefficient = 0)

* $p < 0.10$ (against a two-sided test of a null hypothesis of the bag ban coefficient = 0)

The results associated with the bans in Malibu, Fairfax, and Palo Alto are also statistically significant and consequential. However, as to be expected, the effects are substantially smaller than those found for the San Francisco County ban. Since each of these municipalities represents a small portion of the relevant county's population, the relative effect on ER visits is attenuated.

If we expand attention to the other bacterial infections that lead to hospitalizations, we find consistent evidence as shown in Table 6. In addition to E. Coli, the CDC reports that salmonella, campylobacter, and toxoplasmosis infections lead to significant hospitalizations nationwide.

| Table 6 | | | | |
|---|---|---|---|---|
| Effect of San Francisco County Plastic Bag Ban on ER Admissions | | | | |
| (standard errors clustered at county level) | | | | |
| | E. Coli | Salmonella | Campylobacter | Toxoplasmosis |
| Bag Ban | 0.27***<br>(0.06) | 0.06***<br>(0.02) | 0.24**<br>(0.02) | -0.00<br>(0.01) |
| County FEs | Yes | Yes | Yes | Yes |
| Period FEs | Yes | Yes | Yes | Yes |
| County Trends | No | No | No | No |
| Relative Effect | +32% | +6% | +27% | -0% |
| Observations | 1,130 | 1,130 | 1,130 | 1,130 |

Note: Dependent variable is the natural log of the number of emergency room visits in given county in given quarter where the principal diagnosis code involved the relevant bacterial infection.

*** $p < 0.01$ (against a two-sided test of a null hypothesis of the bag ban coefficient = 0)

** $p < 0.05$ (against a two-sided test of a null hypothesis of the bag ban coefficient = 0)

* $p < 0.10$ (against a two-sided test of a null hypothesis of the bag ban coefficient = 0)

While there is no effect on toxoplasmosis, there are statistically significant increases in salmonella and campylobacter related ER admissions. Although not reported, the effects are similar if the sample is restricted to the Bay Area counties.

### 4.b The San Francisco Bag Ban and Deaths from Infectious Diseases

Bacterial infections related to food contamination can also lead to deaths in extreme circumstances. The San Francisco County ban went into effect in October 2007. Cause of death data are only available on an annual basis, and are currently available through 2009. We examine the period 2005-2009 and include all California counties that have un-censored death counts available for each of these years. This restriction leaves us with the following 10 counties

in addition to San Francisco: Alameda, Contra Costa, Fresno, Los Angeles, Orange, Riverside, Sacramento, San Bernardino, San Diego, and Ventura.

To account for scale differences in the magnitude of deaths across these counties, we examine the natural log of deaths. In our regressions, we include county-level fixed effects and common year effects.

Table 7 provides the results of this regression. We find that the San Francisco County ban is associated with a 46 percent increase in deaths from foodborne illnesses. This implies an increase of 5.5 annual deaths for the county. The effect is statistically significant at better than the 1 percent level. To provide confidence in the causal interpretation of this result, we analyze restricted samples that may provide a better counterfactual for San Francisco County. If we restrict attention to the three Bay area counties, San Francisco plus Alameda and Contra Costa, our estimated effect increases and remains statistically significant despite the decline in sample size. We also examine a sample restricted to counties with percentage changes in deaths between 2005 and 2006 that were similar to San Francisco's increase of 9 percent: Alameda (0 percent); Contra Costa (+12.5 percent); San Bernardino (+15 percent); and Ventura (+11.8 percent). Results for this set of counties were also similar.

| Table 7 | | | |
|---|---|---|---|
| Effect of San Francisco County Plastic Bag Ban on Deaths from Intestinal Diseases | | | |
| (standard errors clustered by county) | | | |
| | ln(deaths from intestinal infectious diseases) | | |
| | All Counties | Bay Area Counties | Comparable Counties |
| Bag Ban | 0.38***<br>(0.03) | 0.40*<br>(0.12) | 0.37***<br>(0.07) |
| County Fixed Effects | Yes | Yes | Yes |
| Year Fixed Effects | Yes | Yes | Yes |
| County-Trends | No | No | No |
| Relative Effect | +46% | +49% | +45% |
| Observations | 55 | 15 | 25 |

Note: Dependent variable is the natural log of the number of deaths in given county in given year attributed to causes listed under the ICD-10 heading "intestinal infectious diseases" (A00-A09) according to the CDC.

*** $p < 0.01$ (against a two-sided test of a null hypothesis of the bag ban coefficient = 0)

** $p < 0.05$ (against a two-sided test of a null hypothesis of the bag ban coefficient = 0)

* $p < 0.10$ (against a two-sided test of a null hypothesis of the bag ban coefficient = 0)

The results concerning deaths are very similar to the ER results provided above. They are also very consistent across the different sample restrictions, suggesting a relative increase of at least 45 percent. Given that there were 12 deaths from intestinal infections in San Francisco County in the year before the plastic bag ban was implemented, this implies an increase of 5.4 additional deaths each year that can be attributed to the ban.

While the small sample size limits our analyses of the death data, examination of county specific trend models provides no evidence that the results discussed above are an artifact of pre-existing trends. The limited sample size also creates some inferential concerns which are compounded by concerns about inference in cases where there are few policy changes, such as those raised in

Conley and Taber (2011) and Gelbach, Helland, and Klick (forthcoming). Following the non-parametric approaches suggested in those papers leads to the conclusion that the results presented here are statistically different from zero, but those approaches do not account for clustering concerns; thus, any inferential claims are tentative. However, the practical significance of the results and the consistency of the ER admission results, including the specification examining multiple bans, suggest that plastic bag bans are associated with important health effects.

## 5. I Like Turtles

Our results suggest that the San Francisco ban led to, conservatively, 5.4 annual additional deaths. Using the EPA's current estimated value of a statistical life, 8.4 million in current dollars, this suggests an annual loss of about $45 million without considering the additional hospital costs, either associated with these deaths or with the increased ER visits documented above, or the personal costs suffered by individuals who do not seek medical care.

Against these costs, in 2004 San Francisco estimated that plastic bag waste cost it $8.5 million annually,[6] which is $10.3 million in current dollars. Especially given that plastic bags are generally estimated to be cheaper to make than substitute bags, this implies that any improvements to the environment owing to the bag ban need to be worth at least $35 million annually to justify the bans on cost benefit grounds.

A precise valuation of the environmental benefits is hard to come by. However, many advocacy groups suggest that plastic refuse (from all sources, not just bags)[7] kills 1 million birds and 100,000 other aquatic animals annually. A conservative estimate is that global plastic bag use is at least 500 billion bags annually, of which 180 million were used in San Francisco prior to the ban.[8] If we assume that a jurisdiction's "share" of animal deaths is proportionate to bag use,[9]

[6] See http://www.cawrecycles.org/issues/plastic_campaign/plastic_bags/problem
[7] The original source upon which this estimate is based actually does not examine plastic bags but instead focuses primarily on plastic fishing equipment. See Laist (1987).
[8] See http://www.sfgate.com/green/article/S-F-FIRST-CITY-TO-BAN-PLASTIC-SHOPPING-BAGS-2606833.php

and we ignore all other sources of plastic, this suggests that San Francisco's annual contribution to animal deaths is on the order of 400 birds and marine animals. This implies a break even valuation of each animal of about $87,500. While it is difficult to put non-use values on these animals, there have been attempts to estimate replacement costs. For example, Brown (1992) surveyed replacement cost estimates for the animals affected by the Exxon Valdez oil spill for the Alaska Attorney General's Office. Even if all of the affected animals were valued at the highest cost found for a bird, $22,000 for an eagle in 1989 dollars ($40,874 in 2012), this falls well short of the break even mark. These numbers are only rough guidelines, but they suggest that the current trend toward bag bans may be difficult to justify on cost benefit grounds.

Despite these concerns, it could be argued that a simple solution exists, namely fastidious washing of the reusable bags. Such a solution is problematic, however. First, washing such bags will itself have negative environmental consequences through excess water use.[10] Further, the detergents necessary to clean the bags add to the environmental costs, as does the use of water hot enough to kill the bacteria.

An additional concern arises from the work of Williams et al, which shows that the normal storage option for these bags (i.e., in a car trunk) multiplies the underlying presence of coliform bacteria substantially. If an individual does not clean and dry the reusable bag completely, such storage might negate the marginal benefits of cleaning the bags in the first place. Lastly, because of the cost savings of plastic bags, which are primarily generated by the use of less energy in their production than reusable bags, reusable bags must be used quite often before they represent a net gain environmentally. For example, the UK Environment Agency (2011) estimated that a cotton bag would need to be used 131 times before it overcame the initial environmental deficit it represented relative to a plastic bag (assuming the plastic bag was used once and discarded). Washing these bags will likely reduce their effective life, reducing the likelihood they represent an environmental benefit.

---

[9] Given San Francisco County's proximity to the ocean, perhaps a greater than proportionate share of plastic bag litter related wildlife deaths ought to be attributed to it.

[10] While marginal costs may be low if bags can simply be added to existing wash loads, there would be some cost involved in using the higher temperature washes that would be necessary to eliminate the bacteria risk.

## 6. Conclusion

State and local governments have recently imposed bans or levied taxes upon plastic grocery bags. This trend is in response to environmental concerns that plastic bags contribute to litter and endanger marine animals. San Francisco County was the first major US jurisdiction to enact such a regulation, implementing a ban in 2007 and extending it to all retailers in 2012. There has been little empirical evidence proffered illuminating the costs and benefits of these bag bans. We undertake such an analysis in light of concerns that consumers might substitute from the banned or taxed bags toward reusable grocery bags, a common substitute and potential carrier of harmful bacteria such as E. coli. We examine deaths and emergency room admissions related to these bacteria in the wake of the San Francisco ban. We find that both deaths and ER visits spiked as soon as the ban went into effect. Relative to other counties, deaths in San Francisco increase by almost 50 percent, and ER visits increase by a comparable amount. Subsequent bans by other cities in California appear to be associated with similar effects. Conservative estimates of the costs and benefits of the San Francisco plastic bag ban suggest the health risks they impose are not likely offset by environmental benefits.

**References**

Brown, Gardner (1992). "Replacement Costs of Birds and Animals."

Cameron, A. Colin, Jonah B. Gelbach, and Douglas L. Miller (2011). "Robust Inference with Multiway Clustering." *Journal of Business and Economic Statistics*, 29(2): 238-249.

Chou, Johnson and Garg, Rahul. "An Investigation into Compostable Plastic Bags." University of British Columbia: SEEDS Student Reports. Web April 2010 <https://circle.ubc.ca/bitstream/handle/2429/29517/APSC262_CompostableBags_Group1_CLEAN%2520FINAL.pdf?sequence=1>.

Conley, Timothy G., and Christopher R. Taber (2011). "Inference with 'Difference in Differences' with a Small Number of Policy Changes." *Review of Economics and Statistics*, 93(1): 113-125.

d2w Inside. "are biodegradable plastic bags more expensive? any way to cost down?" Web 10 September 2010 <http://www.degradableplasticbag.com/blog/bid/46162/are-biodegradable-plastic-bags-more-expensive-any-way-to-cost-down.html>.

Environment Agency (2011). "Life Cycle Assessment of Supermarket Carrier Bags."

Town of Fairfax Code Chapter 8.18 § 8.18.010-8.18.100 (as amended by Town of Fairfax voters, 2008).

Town of Fairfax Code Chapter 8.18 § 8.18.010(z) (as amended by Town of Fairfax voters, 2008).

Finz, Stacy. SFGate. "New SF checkout bag law takes effect Oct. 1." Web 21 September 2012 <http://www.sfgate.com/business/article/New-SF-checkout-bag-law-takes-effect-Oct-1-3881509.php#ixzz27ivCcEJu>.

Florida Dept. of Environmental Protection. “Retail Bags Report - List of Retail Bag Policies - USA” Web 15 August 2009 <http://www.dep.state.fl.us/waste/retailbags/pages/list_USA.htm>.

Gelbach, Jonah B., Eric Helland, and Jonathan Klick (forthcoming). “Valid Inference in Single-Firm, Single-Event Studies.” *American Law and Economics Review*.

Jin, Ginger Zhe and Leslie, Phillip (2003). "The Effect of Information on Product Quality: Evidence from Restaurant Hygiene Grade Cards." *The Quarterly Journal of Economics*, Vol. 118, No. 2 (May, 2003), pp. 409-451.

Laist, David W. (1987). “Overview of the biological effects of lost and discarded plastic debris in the marine environment,” Marine Pollution Bulletin 18, 319–326.

Los Angeles Department of Public Works, “Celebrate a Plastic Bag Free LA County.” Web July 2012 <http://dpw.lacounty.gov/epd/aboutthebag/>.

City of Malibu Municipal Code Chapter 9.28 § 010-020 (as amended by City of Malibu Ordinance No. 323, 2008).

Nashville Wraps. “Paper Bags vs. Plastic Bags – Real Numbers.” Web 17 April 2008 <http://www.nashvillewrapscommunity.com/blog/2008/04/paper-bags-versus-plastic-bags-real-numbers/>.

Oxo-biodegradable Plastics Association. “Briefing Note on Biodegradable Plastics.” Web 18 July 2011 <http://www.biodeg.org/files/uploaded/biodeg/briefing_notes/Briefing_Note_OPA_18_Jun_2011(2).pdf>.

Palo Alto Municipal Code Chapter 5.35 Title 5 (as amended by Palo Alto Ordinance No. 5032, 2009).

Plasticbaglaws.org. “State and Local Laws.” *PlasticBagLaws.org*. Web 15 August 2009 <http://plasticbaglaws.org/legislation/state-laws/>.

San Francisco Environment Code, Chapter 17 § 1701-1709 (as amended by Plastic Bag Reduction Ordinance 81-07-106883, 2007).

City of San Francisco, 2009, Streets Litter Re-Audit.

Williams, David L., Charles P. Gerba, Sherri Maxwell, and Ryan G. Sinclair (2011). “Assessment of the Potential for Cross-contamination of Food Products by Reusable Shopping Bags.” *Food Protection Trends*, 31(8): 508-513.