Did the Swine Flu Save Lives? Evidence from Mexico

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Preliminary Version. Comments Welcome.

Abstract

Diarrheal diseases are among the top causes of child deaths in developing countries. These diseases can be prevented by the simple act of handwashing with soap. However, the current literature shows that only programs with high monitoring are effective in changing behavior and improving health outcomes. These results have sparked interest in understanding the mechanisms through which changes in behavior can occur. In this paper we exploit the spatial variation in the H1N1 influenza (swine flu) outbreak that occurred in Mexico in 2009, and show that areas with higher incidence of the swine flu experienced larger reductions in the number of diarrhea-caused hospital discharges. In particular, we find that for every 1,000 swine flu cases, there was a decrease of approximately 9 percent in the number of hospital discharges of children under five years of age. We validate the robustness of our difference-in-difference estimates using other cause-specific discharges as well as placebo tests before 2009. We present evidence suggesting that handwashing practices are behind these health improvements. Overall, these findings are consistent with the literature of behavioral economics about the role of shocks on changing people risk perceptions.

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1. Introduction

Worldwide, the leading causes of deaths are preventable. In the U.S., for example, nearly half of the deaths in 1990 and 2000 were related to modifiable risk factors such as smoking, poor diets, sedentary life styles, drug use, among others (Mokad, et al, 2004).[1] In developing countries, diarrheal and acute respiratory diseases are responsible for two-thirds of child deaths. For survivors, the occurrence of these diseases results in missed school days for children and lost wages for adults.[2] However, most of these deaths and illnesses are preventable. Handwashing with soap—especially after contact with feces and before handling food— is recommended in order to reduce the incidence of diarrhea and respiratory infections.[3] Yet, handwashing is not a widely adopted behavior in developing countries (Chase and Do, 2010). The World Bank (2005) reports that handwashing with soap rates after defecation or cleaning up a child is at most 35 percent. Sometimes these rates are as low as zero. These low rates have triggered an increase in the number of studies that seek to change the factors behind handwashing with soap behavior by providing information regarding good hygiene practices and improvements in water access and soap.[4]

For example, Luby et al (2005) find that in Pakistan, children younger than 15 years living in households that received plain soap and handwashing promotion had a 53 percent lower incidence of diarrhea than the control households. However, part of the success of the program involved high monitoring that would be extremely difficult and

[1] The most recent causes of death confirm the persistence of this problem (CDC, 2012).
[2] See World Bank (2005), page 9. and WHO (2004).
[3] Ejemot-Nwadiaro et al (2008) review 14 randomized trials and find that handwashing promotion reduces diarrhea in children by 32 percent in developing countries.
[4] This expansion mimics the rapid increase in the number of papers focusing on risky health behaviors in the US and other high-income countries. For a general review of this literature see Cawley and Ruhm (2012).

costly to replicate at a large scale. For instance, their intervention required that fieldworkers visited treated households every week for an entire year.

Surprisingly, in cases where scaling up a monitoring-intensive and well-controlled intervention is feasible, researchers have not observed a reduction in diarrheal cases. A recent report of a large-scale intervention in Peru shows that a province-level mass media campaign alone was not effective in reaching the targeted population and did not improve the knowledge of mothers regarding handwashing with soap (Galiani et al 2012). This same study shows that a more comprehensive district-level community treatment did improve knowledge. However, despite the gains in knowledge and in *self-reported* and *observed* handwashing practices there were no effects on health outcomes for children. These findings are consistent with Meredith et al (2013) that found that information campaigns, which among other health topics discussed the importance of handwashing, had no effect on inducing health prevention investments in soaps or vitamins in India, Guatemala and Uganda.[5] The combined results from localized and scaled-up interventions are puzzling. Why is it that knowledge alone—without high monitoring to ensure or improve compliance—does not lead to health improvements for children? Our paper represents an attempt to answer this question.

In this paper we exploit the regional variation in the intensity of the H1N1 influenza (swine flu) outbreak that occurred in Mexico in 2009. Using a balanced panel of hospital discharges and the total number of laboratory confirmed cases of the swine flu from Mexico's Ministry of Health (*Secretaria de Salud)* we show that states with higher incidence of the swine flu had a larger decline in the number of diarrheal cases relative to

[5] Also, Kremer and Miguel (2007) found no effect of information on Kenyan's investing in deworming treatment, and Ashraf, Berry and Shapiro (2010) reported that information had no effect on chlorine water purification in Zambia.

years preceding the outbreak. This main finding is clearly shown in Panel A of Figure 1. There we compare the number of hospital discharges related to diarrhea during the swine flu outbreak (2009) with those prior to the epidemic (2008). For each state, the difference between these two periods is displayed against the number of confirmed H1N1 cases in 2009. Most of the points are below the zero axes, which indicate that there was a decrease in the number of diarrheal cases during the 2009 epidemic but the decline is *larger* in the states with a larger swine flu incidence.

A battery of robustness checks supports our results. For example, we validate our empirical strategy using other cause-specific discharges that serve as a placebo test. In Panel C of Figure 1 we show that hospital discharges related to injuries, as expected, are not related with the incidence of the H1N1 flu at the state level. Second, we expand our robustness checks by considering only the pre-swine flu period. Specifically, we find no association between diarrhea related discharges between 2008 and 2007 and the number of confirmed swine flu cases in 2009 (Figure 1, Panel B).

Our findings indicate that the incidence of the H1N1 epidemic led to an improvement in the health outcomes of the population with respect to diarrheal cases. We find that the bulk of the effect is concentrated in younger children: four or younger. These effects indicate that every 1,000 cases of the swine flu reduced hospital discharges by 9.4 percent. We consider a set of factors as possible mechanisms behind the improvements and present evidence suggesting that handwashing might have a play a key role. These findings are consistent with recent models of behavioral economics where large health shocks alter the risk perceptions of individuals (e.g., Sloan, Smith and Taylor, 2003 and Cawley and Ruhm, 2012).

The paper is divided in five sections, including this introduction. In the next section we briefly describe the H1N1 outbreak in Mexico. Section three describes the data sources and our econometric model. The main results are presented in section four. The discussion of our findings and the conclusions of the paper are included in section five.

2. Mexico and the 2009 H1N1 Flu Outbreak

In March and early April 2009, Mexico experienced an outbreak of respiratory illness which was later confirmed to have been caused by the novel influenza H1N1 virus or *swine flu*. The World Health Organization declared this outbreak to be the first pandemic in 41 years. As of June 2011, Mexico's Ministry of Health reported that there were more than 70,000 confirmed cases of swine flu in 2009, including more than 1,000 deaths and more than 2,400 hospitalizations. The average hospital stay was six days. Most of the confirmed cases in Mexico involved a relatively younger cohort, 10-39 year-olds, than what is typically affected by the seasonal wave of influenza. Fifty-two percent of the confirmed cases involved women, but, fifty-one percent of the deaths for which the H1N1 infection was confirmed involved men.[6]

The Mexican government instituted several measures to slow disease transmission, including social distancing and mandatory closure of all schools, daycares, and non-essential businesses throughout the country. There was also an intense mass media campaign advocating the importance of respiratory hygiene/cough etiquette. Specifically, the goal of the campaign was to educate the public about frequent and proper

[6] The proportion of confirmed swine flu for the following age groups 0-9, 10-19, 20-39, and 40+ 26 percent, 28 percent, 30 percent, and 16 percent, respectively, SSA (2011).

handwashing technique, covering sneeze/cough, using facemasks and hand sanitizers, seeking care if ill, and discouraging self-medication. We will return to the health campain issue and how it might help us expain our findings later in the discussion section.

All states in Mexico were affected by the swine flu outbreak, but there was variation in the frequency of cases across states.[7] Appendix Table A1 lists the number of confirmed cases across the states of Mexico in 2009; Mexico City had the highest number of cases and the state of Campeche had the lowest. There were three waves (or outbreaks) of H1N1 infection that occurred during 2009. The causes of the outbreaks are still unknown, although some hypothesize the first wave might have initiated after a large gathering that occurred during Easter in a place near Mexico City. During the first outbreak, states that were in close geographic proximity to Mexico City had a higher incidence of cases than states farther away. The second wave coincided with the summer school vacation period during which many travel to the Southern parts of Mexico. Finally, the 2009 fall wave coincided with the going back to school period for more than 30 million students from elementary school to university. Appendix Table A1 summarizes the variation across geographic areas for each of the waves that occurred in 2009 as classified by Chowell et al (2011). We also find a positive correlation between the number of swine flu cases and public interest as measured by the number of calls to a help/hotline established by the Ministry of Health during the outbreak (see Figure 2)

[7] The Federal District, or Mexico City, is not a state, but we refer to it as a state henceforth.

3. Data and Methods

We use two main data sources for this paper both collected by Mexico's Ministry of Health (*Secretaria de Salud*). First, we use hospital discharge data from all public hospitals. The data is available since 2002 and for the purpose of this study we focus on 2007-2011 period. Common to many developing countries, the public hospital system covers most of the population and in the case of Mexico, 85 percent of all hospital visits are covered by public hospitals. This large coverage strengthens the external validity of our findings.[8,9]

Each entry of the hospital discharge data reports the geographical location of the discharge (i.e, state, county and district), the date of entry and exit, as well as some demographic information about the patient such as gender and age. A key advantage of this dataset is that the coding for the main reason for discharge follows the International Statistical Classification of Diseases and Related Health Problems 10th Revision or ICD-10, created by the World Health Organization (WHO, 2004.) Based on this classification, we consider the cases where the initial diagnosis is gastroenteritis and colitis of infectious origin (or diarrhea) coded as A09X. We focus on this particular disease code because this is mainly transmitted through hands. In our robustness checks we consider disease codes A00 to A008, which include non-infective diarrhea (K52.9) and intestinal infections due

[8] Mexico's Ministry of Health reports that in 2009, there were 91.6 million users of the public hospital system. Sistema Nacional de Informacion en Salud (SINAIS). Población usuaria por entidad federativa según institución, 2009, Boletin de Informacion Estadistica, Vol. III, Servicios Otorgados y Programas Sustantivos, Numero 29, Año 2009, http://www.sinais.salud.gob.mx/publicaciones/index.html, accessed November 24, 2013.

[9] The report does not indicate whether the reported 91.6 million users include repeated users.

to bacterial, protozoal, viral and other specified infectious agents. These diseases involve pathogens that are *not* mainly transmitted through hands, e.g., food poisoning.[10]

It is important to note that the use of hospital discharges implies that we are concentrating on the extreme cases of diarrhea, that is, those leading to hospitalization and possible death.[11] Thus, observing declines in these cases due to the H1N1 is of high importance for public health officials. Moreover, the use of administrative data reduces the possible measurement error problem from self-reported household data as is common in most of this literature.

Children under five represent 51 percent of all hospital discharges due to diarrhea.[12] For this reason we will focus our analysis mainly on this age group. Children aged between 5 and 14 represent only 15 percent of all the diarrhea discharges while people 45 and older constitute 20 percent of the cases. When considering gender, across all ages, men and women have equal shares in the distribution of diarrhea discharges. However, in the 0-4 group, boys account for 57 percent of the diarrhea hospitalizations. This gender division does not change when all other forms of intestinal infections are included.

The second data source comes from the variation in laboratory-confirmed swine flu cases –coded as J09 in ICD-10– across states in 2009. We exploit the temporal (no

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[10] In the robustness section, we discuss the results when we add cases in ICD-10 A00-A008. See also Appendix Table A2 for further details on what the ICD-10 codes include.

[11] While mortality is interesting in its own right, we do not investigate this as a separate outcome because there is little variation in the data--approximately 0.4 percent of the hospital discharges are due to death. However, in the results section we briefly discuss the implications of our findings as they pertain to mortality.

[12] There were 5.8 million hospital discharges in Mexico in 2011 -456.3 discharges per 10,000 population- and 129,000 cases were related to diarrhea representing 2.1 percent of all discharges. However, of all the discharges related to children under five, 6.2 percent are due to diarrhea.

swine flu before 2009) and cross-sectional variation (by state) of the swine flu to examine its effect on diarrhea cases, that is, diseases that may be prevented with improved hygiene behavior that followed the swine flu outbreak. This difference-in-difference identification strategy is formally presented in equation (1),

$$y_{st} = \alpha + \beta \text{ H1N1}_s\text{*Treat}_{st} + \tau_t + \theta_s + e_{st} \qquad (1)$$

where y_{st} is the number of hospital discharges whose initial diagnosis was diarrhea (A09X) for state *s* in year *t*. Variable *H1N1* represents the number of laboratory-confirmed swine flu cases reported in each of the states for the year 2009. We use H1N1 counts rather than rates because we believe that part of the mechanism through which individuals' perceptions changed was rooted in the perceived magnitude of the problem as reported on news media channels. The news media reported the total number of cases that had been confirmed at the national as well as the states where the highest of cases had been confirmed.[13] *Treat* is an indicator equals to one if the hospital discharge occurred in the treatment period (during the 2009 H1N1 outbreak) and zero otherwise. In our main specification we compare the cases prior to the outbreak (i.e., 2008) relative to the year of the swine flu outbreak (2009.[14])

Equation (1) includes controls for year, τ_t , and state, θ_s, fixed effects. The year fixed effects allow us to control for nationwide trends in diarrheal diseases while the state fixed effects account for time-invariant unobserved characteristics during the period of

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[13] See for example, http://www.eluniversal.com.mx/notas/629954.html, and http://www.eluniversal.com.mx/notas/636158.html, accessed November 4, 2013.

[14] We also investigate alternate treatment periods. The results of these specifications are discussed in the robustness section.

analysis at the state level. Therefore, we rule out the possibility that our findings could arise from unobservables explaining -at the same time- why states had higher cases of the swine flu and (fewer) cases of diarrhea. These unobserved variables include income, population size and growth and due to the short period of analysis, these time-invariant characteristics include also the stock of hospitals and clinics. If the outbreak induced changes in hygiene behavior, we would expect to observe a *larger* decrease in the incidence of diarrheal diseases of infectious origin in states where the swine flu was *more* prevalent, after controlling for the controls described in equation (1). In other words, we would expect β to be negative and statistically significant. In the next section, we show the results of estimating equation (1) with the data described above. We complement our findings with several falsification tests.

4. Did the Swine Flu Save Lives?

4.1 Main Findings

Table 1 presents the results from running the specification presented in equation (1) where the treatment period is 2009 and the control period is 2008. In other words, we are estimating the contemporaneous effect of the H1N1 on diarrhea cases. We first pool together the data for all ages and genders. For this full sample, in Panel A, column 1, the estimated value for the coefficient of interest has the expected negative sign (-0.057). That is, there were *fewer* hospital discharges related to diarrhea in areas with *more* swine flu cases, even after controlling for time and state fixed-effects. However, the estimate is not statistically significant. In columns 2 to 6 we explore this relationship for different age groups. We find a negative and statistically significant negative effect coming mainly from the population under five (column 2.) Specifically, the coefficient of *H1N1*Treat* is -0.093 and it is statistically significant at the one percent level. This coefficient implies that for every 1,000 cases of the swine flu, there were 93 fewer cases of diarrhea in children under 5 years of age in future periods. Given the average number of diarrhea-related hospitalization for this group (993 in the period 2008-2009), the estimated association indicates that for every 1,000 cases of the swine flu we observe a 9.4 percent decline in diarrhea-related hospitalizations of children under five (-0.093*1000/993.) That is, 3,404 cases of the H1N1 (or 4.9 percent of all confirmed cases) would have the same effect in the reduction of diarrhea (32 percent) as the estimated average effect from the costly interventions reviewed by Ejemot-Nwadiaro et al (2008). Furthermore, using the death rate among children under 5 in the hospitalization discharge data (approximately 0.4 percent), we estimate that for every 1,000 cases of the swine flu, 3.75 deaths (93*0.040) due to diarrhea might have been prevented.

Panel A of Table 1 also shows the effects for other age groups (columns 3-6). In all cases, we find no relationship between H1N1 cases and hospital discharges related to diarrhea and the point estimates are substantially lower relative to the children under five. This constitutes our main finding: the negative association between swine flu cases and hospitalization due to diarrhea is clearly found in young children (under five) and not for other age groups. This finding will not change when the data are divided by gender and is robust to several alternative definitions of diarrhea and falsification tests as shown below.

We now explore differential effects by gender (Table 1, Panels B and C.) We do this for two reasons. First, for the case of young children, boys are over represented in diarrhea cases as shown in the previous section. Second, it is plausible that behavioral responses, e.g., improvements in hand washing behavior, also vary by gender. We confirm our main results and continue to find that the effects are concentrated on children under five. For boys under five (Panel B, column 2), we find that for every 1000 cases of the swine flu there was an 11 percent reduction in hospitalizations (-0.063*1000/566) and a 7 percent (0.031*1000/427) reduction for their female counterparts (Panel C, column 2). These results imply that the effect is larger for the gender group that was previously more affected by diarrhea and therefore reducing the gender inequities. For the rest of the paper we will focus the analysis on the under five population given that the main effects are concentrated on the youngest population group, which is validated when we divide the data by gender. If needed, the results for the other age groups are available upon request.

4.2 Alternative Definitions of Diarrhea

In our preferred specification, the outcome measure is the number of cases classified as ICD-10 A09X, that is, diarrhea and gastroenteritis from infectious origin, which excludes infectious cases caused by bacteria, protozoa, viruses and other specified infectious agents[15]. As discussed above, the choice of this measure is based on the fact that these types of diarrheal cases are more directly tied to handwashing with soap behavior (SSA 2008). However, there are cases of diarrhea caused by infectious agents, e.g., cholera, bacterial foodborne intoxications, e-coli infections--these cases are classified in ICD-10 codes A00-A08—which could be affected by behavioral changes in hygiene. As a result, we investigate how changing the outcome measure alters our results (see Table 2).

[15] See Appendix Table A1 for further description of the ICD-10 codes used in this analysis.

For convenience, in column (1) of Table 2 we include our previous the results for cases of diarrhea classified as A09X. In column (2), we present the results when the outcome measure includes all intestinal infections, A00-A08 and A09X. The results show coefficients that remain relatively unchanged in magnitude (-0.093 vs. -0.105) and in its level of statistical significance. As before, still on column (2), we find that the effects are larger in boys than in girls. When we only consider those cases transmitted by infectious agents (A00-A08 only), that is, the cases where handwashing with soap will have less of an impact, we find that the coefficients are still negative albeit much smaller (column 3) when compared to those in column (2), and marginally significant at the 10 percent level. We conclude that diarrheal cases caused by pathogens that are not mainly transmitted by hands were not affected by the H1N1. This result represents the first piece of evidence suggesting that the swine flu created a change in hygiene practices that led to the reduction in diarrhea cases.

4.3 Robustness Checks

A question that arises is whether we attribute changes to the outcome of interest to the intensity of H1N1 cases, rather than to pre-existing trends. We conduct two falsification tests to evaluate this possibility. We start by examining the impact of the intensity of the H1N1 outbreak on the period preceding 2009. Our identification strategy relies on the assumption that the pre-2009 characteristics cannot predict the intensity of the 2009 outbreak; otherwise, these pre-2009 features could be simultaneously affecting the outbreak and the outcome in 2009. To rule out this possible confounding effect we run the same specification as in equation (1) for the outcomes A09X (diarrhea that could be reduced by handwashing with soap) and A00-A08 plus A09X (all causes) but for two years prior to the outbreak: 2007 vs. 2006. The results of these specifications are shown in columns (1) and (2) of Table 3. In our preferred specification (A09X, column 1), the difference and difference estimates for this falsification test show a *positive* association between H1N1 cases diarrhea cases prior to 2009. This goes in the opposite direction compared to our main finding of a reduction in diarrhea cases between 2008 and 2009. We observed the same positive parameters, but again never statistically different from zero at the five percent level, when we examine the outcome measure A00-A08 and A09X. The lack of a negative and statistically significant effect serves as a clear validation of our identification strategy.

For our second set of falsification tests, we go back to comparing data from 2008 vs. 2009 for the three new outcomes: acute respiratory infections (ARIs), injuries caused by external factors[16] (e.g. traffic accidents), and all hospital discharges. We explain each of the outcome measures and the results in turn. First, diarrhea and ARIs can both be caused by viral infections. If the H1N1 pandemic resulted in improvements in diagnosing ARIs, the observed decrease in the number of diarrheal cases could be a mechanical artifact: what was *incorrectly* classified as a diarrhea case prior to the H1N1 becomes an ARI as doctors and nurses are able to identify these cases with less measurement error. In this case, one would expect to see an increase in the number of ARIs in areas with more H1N1 cases and such a positive effect would go against the possibility that handwashing with soap is a leading mechanism. We test for this possibility in column (3) of Table 3. In Panel A, for males and females combined, we observe a very small positive effect and

[16] Injuries includes trauma to body, burns, poisoning due to external factors such as falls, traffic accidents, self-inflicted injuries, exposure to inanimate falling, thrown or projected objects, and aggressions.

that is not statistically different from zero. The point estimate is 0.023, which is less than a fourth of the effect on diarrhea, in absolute value. Furthermore, the lack of significance is not due to the ARI estimates having larger standard errors. On the contrary, these standard errors are of the exactly the same magnitude of the diarrhea estimates. These findings are also observed in Panels B and C when we focus on males and females cases separately. Thus, the evidence seems to reject the possibility that an improvement in accuracy in diagnosis of ARI is behind our main results.

Second, because injuries should not be affected by the swine flu outbreak, we would expect to find statistically insignificant effects when we estimate equation (1) using injuries as an outcome. This is precisely what we find in column (4) of Table 3. The effects are true zeroes: very small effects with smaller standard errors. For example, the point estimate is .005 for the sample of males and females combined (Panel A), which is twenty times smaller than the corresponding estimate for diarrhea (in absolute value.) Thus, we rule out the possibility that our difference-in-difference estimator is capturing other unobserved variables affecting at the same time the swine flu outbreak and the hospital discharges related to diarrhea.

Third, another possibility we want to rule out is that we are not attributing our main findings to changes in healthcare-seeking behavior, namely, that there were fewer people going to the hospital in areas with higher prevalence of the H1N1 in order to avoid contact with sick individuals. This is explored in column (5) of Table 3. We do not find evidence in favor of a reduction in overall hospital discharges in areas with more H1N1 cases. If anything, we observe an increase in the number of hospitalizations. Thus, we can rule out the possibility that our findings come from people avoiding hospitals during the swine flu outbreak.

4.4 Are the Effects Persistent?

An important contribution of our paper is the capacity to test whether the effects remain over time. In the previous paragraphs we have shown that the emergence of swine flu is associated with a reduction in the most severe cases of diarrhea as judged by the decline in hospital discharges. We have presented robust evidence in favor of the causal nature of these effects, thereby ruling out pre-trends affecting both, the H1N1 and diarrhea cases and other possible alternative explanations. In this regard, our paper shows how a shock could lead to improvements in health outcomes. While other interventions have been able to show the contemporaneous effect of information campaigns on reduction in diarrhea cases (see for examples the 14 papers reviewed by Ejemot-Nwadiaro, et al, 2008) there is no evidence, to the best of our knowledge, of whether those reductions will be sustained after the campaign ends.

In Table 4 we address this in the literature. We have data for hospital discharges for 2010 and 2011 in addition to 2009. Thus we estimate equation (1) comparing the outcomes for A09X in 2008 against 2009 but also against 2010 and 2011.[17] To ease the comparison, we reproduce our main result in column (1). In column (2) we show that the reduction in diarrhea cases for 2010 is larger: -0.14 compared to -0.09 in 2009 (Panel A). For 2011, the effects are even larger. For every 1,000 cases of the swine flu we observe 163 fewer cases of diarrhea. In relative terms, every 1,000 H1N1 cases reduced diarrhea

[17] At the time of writing this version of the paper the data for 2012 has not been released yet.

hospitalization by 9.4 percent in 2009 and by 15.7 percent by 2011. Thus, the change in behavior is not only persistent but it continuous to improve over time.

5. Possible Mechanisms

How did the swine flu reduce diarrhea cases? In the previous section we have already suggested one possible explanation: the swine flu created a change in hygiene practices that led to more handwashing with soap and to fewer extreme diarrhea cases requiring hospitalization. So far we have presented evidence in favor of this mechanism. For example, we have shown that the decline occurred for diarrhea that could be eliminated via handwashing with soap and not from diarrhea that originates from food poisoning (Table 2). In this section with provide further evidence in favor of this mechanism.

We start by showing that Mexicans became more aware of the need to have better hygiene practices. Figure 3, Panels A and B, show the trend of public interest for hand sanitizers between 2007 through 2011 using data from Google searches in Mexico. There is a growing number of papers using data from Google searches (available at http://www.google.com/trends/) to uncover economic issues. For example, these data has been use to predict economic indicators in US and Germany (Choi and Varian, 2011; Askitas and Zimmermann, 2009; Damuri and Marcucci, 2009) as well as discrimination and voting against US President Barak Obama (Stephens-Davidowitz, 2013.) Google even has a site dedicated to predict the incidence of the seasonal flu based on the results from a paper published in Nature (Ginsberg et al, 2008.) Thus, we display the number of searches originated from Mexico of the word for handsanitizers: “gel” or “gel antibacterial”. To understand the y-scale of Figure 3, it is important to note that Google does not release the actual number of searches but instead provides an index where the highest number of searches is set to 100.

In Figure 3, Panel A we show the weekly searches throughout 2009. The pattern is clear. Prior to week 15 (early April) there are searches of the word hand sanitizer. However, at the time of the swine flu outbreak in early April we see a spike in the number of searches of more than five times relative to first weeks of the year. The post-outbreak trend remained at a level that was higher than the pre-outbreak levels. We further expan this analysis in Panel B of Figure 3 where we show the searches before and after 2009 (but keeping the index equal to 100 at week 15 of 2009). The black (solid) and blue (long-dashed) lines represent 2007 and 2008, respectively while the red and green lines, capture 2010 and 2011, respectively. We show that prior to 2009, the interest in hand sanitizers was consistently around the same for 2007 and 2008—showing only spikes that appear to be seasonal. These seasonal patterns are repeated in 2010 and 2011; however, the magnitude of the Google searches increased significantly and remained high throughout the post-2009 period.[18]

Did the internet searches for hand sanitizer imply actual use of these products? We lack data for purchases in Mexico. However, purchases of hand sanitizers in the United States spiked during the swine flu that also affected this country. Panel A of Appendix Figure A1 shows that retail purchases of hand sanitizers increased significantly in late March/ early April of 2009 and they remained at levels that were higher than the pre-March 2009 period. In addition, Panel B shows that compared to other preventive

[18] Similar patterns –a spike around week 15 and higher searches relative to the pre-outbreak period– can be observed for Google searches of word facemasks or “cubrebocas” (not shown but available upon request.)

products such as thermometers and multi-vitamins, purchases of hand sanitizers represented the largest increase in 2009. Unfortunately, it is not possible to replicate these graphs for Mexico.[19] However, Mexican manufacturing data indicate that between 2008 and 2009, there was a 6.4 percentage point increase in production of soaps, cleaners and cosmetics; this was a significant change as the percentage point increase in the period 2003 to 2007 had been at most 2.3 percentage points.[20]These numbers underestimated purchases as imports of hand sanitizers are not included.

In addition to the changes in production of soaps there is other evidence that suggests changes in handwashing behavior might have occurred during the outbreak. For example, Padilla Raygoza et al (2009) report that Mexican drug stores ran out of facemasks and cold medicine during the outbreak. Furthermore, a survey conducted in Mexico City and two states with varying prevalence of the swine flu showed that the top three mitigation efforts adopted by Mexican citizens to protect against the H1N1 virus included frequently washing of hands with soap, use of a mask, and hand sanitizer (Aburto et al, 2010).[21] We reproduce these findings in Table 5. The table also shows that people in states with higher incidence of the swine flu at the time of the survey had

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[19] Correspondence with Nielsen Co. indicated that data on purchases of hand sanitizers were not available for 2009. However, although we are uncertain about the methodology, one source has indicated that a survey conducted by Nielsen Co. showed that that top two measures adopted by consumers were: 1) the use of face masks and 2) hand washing with soap and water or hand sanitizers. In this same article, Nielsen is cited as a source that reports an increase in consumer purchases of soaps and hand sanitizers in Mexico. http://economia.terra.cl/noticias/noticia.aspx?idNoticia=200906171913_TRM_78156849, accessed November 19, 2013.

These data are not available at the state level.

[21] Although we are uncertain about the methodology, others have indicated that a survey conducted by Nielsen showed that that top two adoption measures adopted by consumers was 1) the use of face masks and hand washing with soap and water or hand sanitizers. Nielsen also reported an increase in sales of soaps and hand sanitizers.
http://economia.terra.cl/noticias/noticia.aspx?idNoticia=200906171913_TRM_78156849, accessed on November 24, 2013.

higher usage of hand sanitizer, which supports our hypothesis that the H1N1 changed hygiene practices, leading to more handwashing with soap or at least more use of hand sanitizers and this change led to a reduction in hospitalizations due to diarrhea. This change is also consistent with behavioral changes reported during an outbreak of Severe Acute Respiratory Syndrome (SARS). Leung et al (2004) report that adoption of preventive behavior was higher for individuals living in Hong Kong than for those living in Singapore where the incidence of SARS was lower.[22]

We finish the discussion about mechanisms exploring whether the health expenditures at the state and federal level played any role in the decline of diarrhea cases. To address this issue we rerun our preferred specification (comparing cases of A09X in 2008 vs. 2009) in equation (1) and include controls for health expenditures at the state level (H_{st}). Formally:

$$y_{st} = \alpha + \beta \, H1N1_s{*}Treat_{st} + \gamma H_{st} + \tau_t + \theta_s + e_{st} \qquad (2)$$

If the government health spending played a role in the reduction of diarrhea cases, we should expect β to be smaller (in absolute value) once we estimate equation (2) because part of the effect would be captured by γ. Table 6 shows that the magnitude and statistical significance of our difference-in-difference estimates remain unchanged after including state (column 2) and state and federal health expenditures (column 3). Thus, the

[22] For example, in Hong Kong 94.4 covered their mouth compared to 83.6 in Singapore. Washing hands immediately after sneezing, coughing or rubbing nose was reported by 85.6 of respondents in Hong Kong, and 72.6 percent of respondents in Singapore. Wearing a mask was reported in 79 percent of respondents in Hong Kong and 4 percent of respondents in Singapore. All these differences were statistically significant at the one percent level.

reduction in diarrhea cases generated by the H1N1 outbreak is unlikely to come from changes in government health expenditures.

6. Conclusions

This paper shows that severe shocks such as the H1N1 outbreak in Mexico led to improvement in health outcomes by reducing the morbidity and mortality associated to diarrheal cases. Several placebo and robustness checks validate our difference-in-difference identification strategy and strengthens the interpretation of our estimates as causal. We present evidence supporting the hypothesis that the outbreak created a major change in hygiene practices, increased the need to acquire information about better practices and motivated people living in areas with higher prevalence of the swine flu to wash their hands or at least to increase their usage of hand sanitizers.

These robust facts are consistent with current findings in other health aspects. For example, Sloan, Smith and Taylor (2003) show that adult smokers are more likely to stop smoking if they suffer from a health shock such as a heart attack compared to smokers who did not experience a negative shock and despite the facts that both groups had similar knowledge of the dangers of smoking. The evidence in this paper suggests that changes in the perception of risk is not continuous as suggested by recent literature in behavioral economics (Smith et al, 2001).

Finally, our findings raise two issues regarding policy implications. First, we show that government health expenditures are unlikely to be behind the reasons for the decline in diarrhea cases. Why these expenditures where ineffective requires further investigation beyond the scope of this paper. Second, health outbreaks such as the one studied in this paper could have unanticipated positive effects as long as the population is willing to change behaviors. This raises the possibility for the private sector, and firms in particular, to play an important role. As discussed by Ippolito and Mathios (1990, 1995) when producers are allowed to reveal the advantages of their products, they provide key information to consumer who then react to this news. Thus, it is important for firms to be able to provide consumers with similar information during heath outbreaks, such as the swine flu, in order to improve hygiene practices and reduce the morbidity and mortality of the most vulnerable population groups.

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Figure 1. Changes in Hospitalizations for Children under Five Years of Age

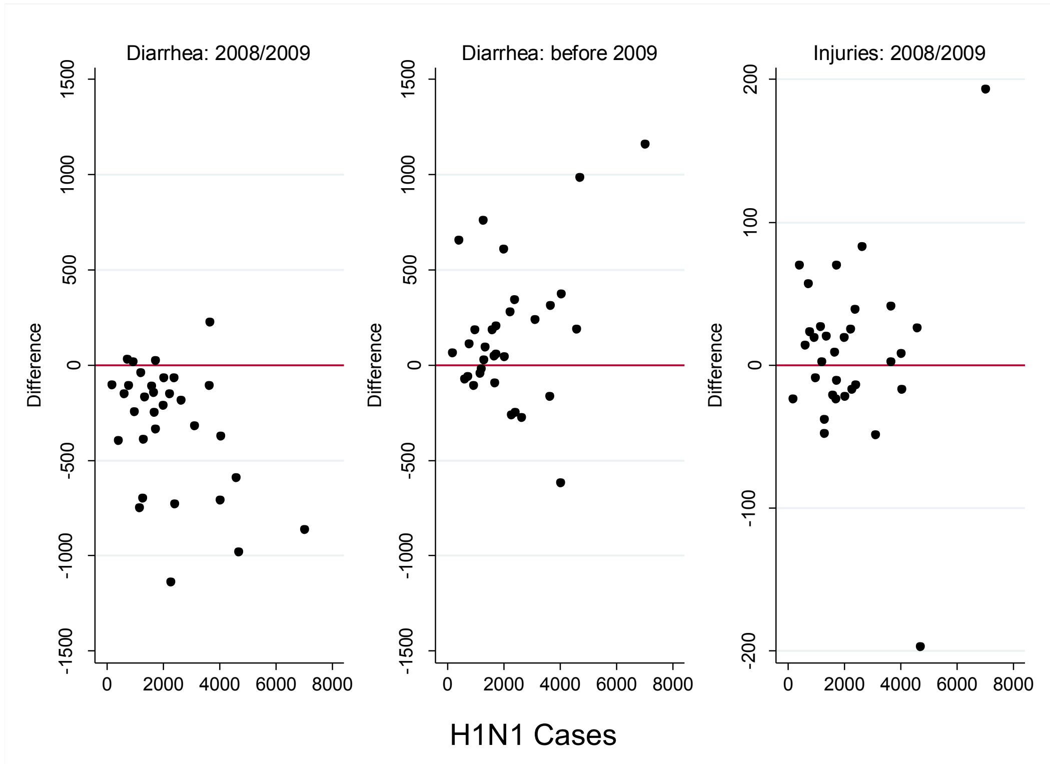
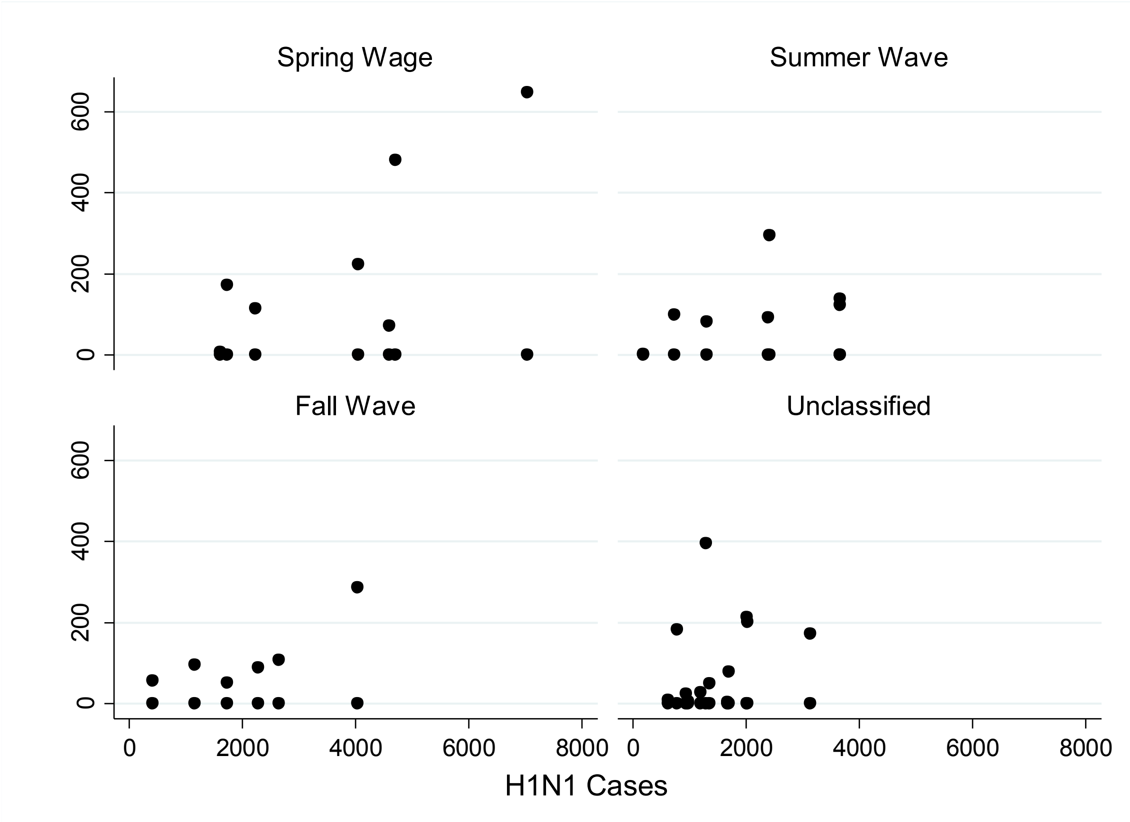


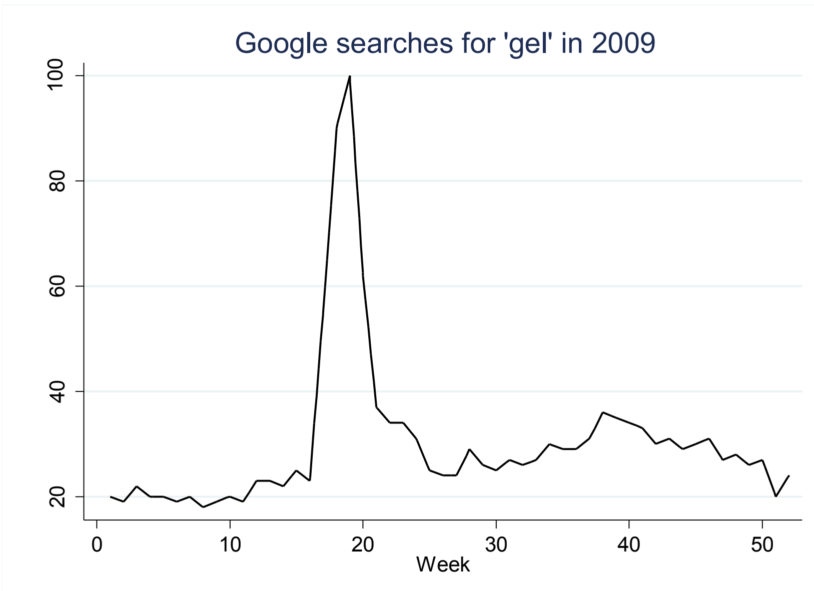
Figure 2. Number of Calls to Hotline and Prevalence of H1N1 by Wave, 2009



Notes: Each pairwise observation represents one unique state. States in each wave as classified by Chowell et al (2011), and number of calls to hotline from each state as reported by Secretaria de Salud (2010).

Figure 3. Google Searches for Hand Sanitizer Information

Panel A. Google Searches for “gel” in 2009



Pane B. Google Searches for “gel” pre- and post-2009.

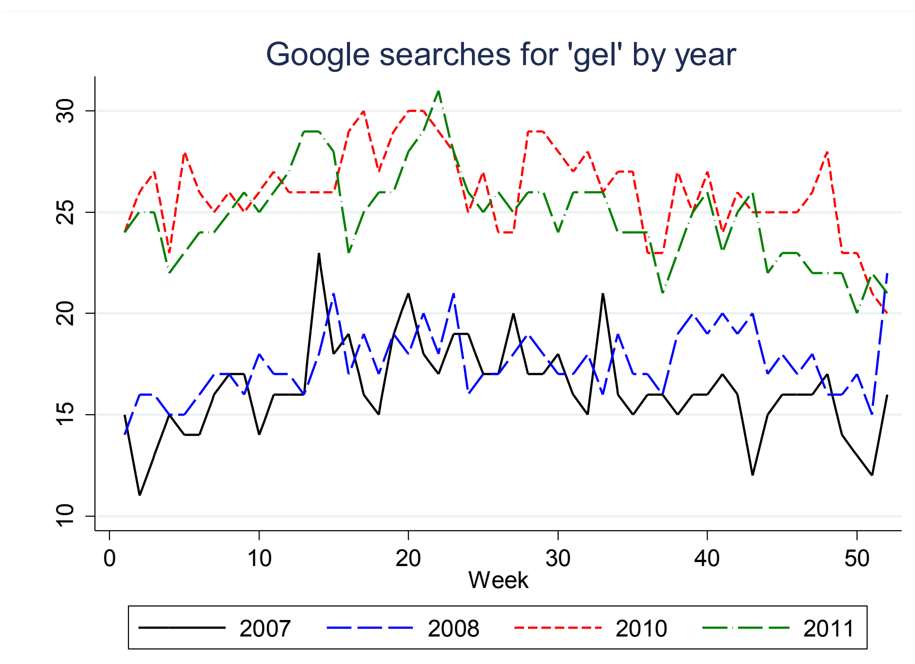


Table 1. Impact of H1N1 Prevalence on Diarrheal Diseases: Sample Includes 2008 *vs* 2009

	Ages					
Treatment Period	All	0-4	5-14	15-21	22-44	45+
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: All						
H1N1*Treat	-0.057	-0.093***	0.022	0.001	0.000	0.014*
	(0.04)	(0.03)	(0.02)	(0.00)	(0.01)	(0.01)
Mean	1,937	993	286	62	205	392
Panel B: Males						
H1N1*Treat	-0.046**	-0.063***	0.011	0.001	0.000	0.005
	(0.02)	(0.02)	(0.01)	(0.00)	(0.00)	(0.00)
Mean	971	566	155	28	84	138
Panel C: Females						
H1N1*Treat	-0.011	-0.031**	0.010	0.000	0.000	0.009*
	(0.02)	(0.01)	(0.01)	(0.00)	(0.00)	(0.01)
Mean	966	427	131	35	120	253

Notes: *** p<0.01, ** p<0.05, * p<0.1. Robust standard errors in parentheses. Standard errors are clustered at the state level. Outcome variable is number of hospital discharges where the initial diagnosis was diarrhea and gastroenteritis from infectious origin (International Classification of Diseases ICD-10 code A09X). Each cell represents a separate regression. The indicator variable *Treat* is equal to one when the discharge occurred in 2009, and it is zero if it occurred in 2008. All regressions include time and state fixed effects. Mean denotes the mean of the dependent variable for each specification and for the period of analysis.

Table 2. Impact of H1N1 Prevalence of Intestinal Infections for Children Under 5

	2008 *vs* 2009		
Outcome (ICD-10 Code):	Diarrhea and Gastroenteritis from Infectious Origin (A09X) (1)	Intestinal Infections (IF) (A00-A09X) (2)	IF, Excludes Diarrhea (A00-A08) (3)
Panel A: All			
H1N1*Treat	-0.093***	-0.105***	-0.011*
	(0.03)	(0.03)	(0.01)
Mean	993	1,117	124
Panel B: Males			
H1N1*Treat	-0.063***	-0.068***	-0.005
	(0.02)	(0.02)	(0.00)
Mean	566	636	70
Panel C: Females			
H1N1*Treat	-0.031**	-0.037**	-0.006*
	(0.01)	(0.01)	(0.00)
Mean	427	481	54

Notes: *** p<0.01, ** p<0.05, * p<0.1. Robust standard errors in parentheses. Standard errors are clustered at the state level. Outcome variable is number of hospital discharges where the initial diagnosis was the respective International Classification of Diseases (ICD-10) code in parentheses. Each cell represents a separate regression. For the period 2008-2009, the indicator variable *Treat* is equal to one if the discharge occurred in 2009 and zero if the discharge occurred in 2008. All regressions include time and state fixed effects.

Table 3. Robustness Checks: Impact of H1N1 Prevalence on Select Outcomes for Children Under 5

Period:	Pre-2009		2008 vs. 2009		
Outcome (ICD-10 Code):	Diarrhea and Gastroenteritis from Infectious Origin (A09X)	Intestinal Infections (A00-A08 and A09X)	Acute Upper Respiratory Infections (J00-J06)	Injuries (S00-T98)	All Hospital Discharges
	(1)	(2)	(3)	(4)	(5)
Panel A: All					
H1N1*Treat	0.085	0.114	0.023	0.005	0.223
	(0.06)	(0.07)	(0.03)	(0.01)	(0.31)
Mean	1,236	1408	471	831	15,953
Panel B: Males					
H1N1*Treat	0.045	0.061*	0.013	0.006	0.088
	(0.03)	(0.04)	(0.02)	(0.01)	(0.16)
Mean	708	807	280	483	9,708
Panel C: Females					
H1N1*Treat	0.041	0.053	0.010	-0.001	0.135
	(0.03)	(0.04)	(0.01)	(0.01)	(0.15)
Mean	526	601	191	349	6,874

Notes: *** p<0.01, ** p<0.05, * p<0.1. Robust standard errors in parentheses. Standard errors are clustered at the state level. Outcome variable is number of hospital discharges where the initial diagnosis was the respective International Classification of Diseases (ICD-10) code in parentheses. Each cell represents a separate regression. For the period pre-2009, the indicator variable is equal to one when the discharge occurred in 2007, and it is zero if it occurred in 2006. For the period 2008-2009, the indicator variable treat is equal to one if the discharge occurred in 2009 and zero if the discharge occurred in 2008. All regressions include time and state fixed effects.

Table 4. Persistence of Effects: Impact of H1N1 Prevalence on Diarrhea and Gastroenteritis from Infectious Origin (A09X) for Children Under 5

	Comparison Group: 2008 vs.		
	2009	2010	2011
	(1)	(2)	(3)
Panel A: All			
H1N1*Treat	-0.093***	-0.144***	-0.163***
	(0.03)	(0.04)	(0.04)
Mean	993	1,061	1,037
Panel B: Male			
H1N1*Treat	-0.063***	-0.086***	-0.097***
	(0.02)	(0.02)	(0.03)
Mean	566	600	588
Panel C: Female			
H1N1*Treat	-0.031**	-0.059***	-0.065***
	(0.01)	(0.02)	(0.02)
Mean	427	460	449

Notes: *** p<0.01, ** p<0.05, * p<0.1. Robust standard errors in parentheses. Standard errors are clustered at the state level. Outcome variable is number of hospital discharges where the initial diagnosis was International Classification of Diseases (ICD-10) code A09X (Diarrhea and Gastroenteritis from Infectious Origin). Each cell represents a separate regression. For all periods, the control period is 2008, and the treatment period is 2009, 2010, and 2011 for each of the respective columns. All regressions include time and state fixed effects.

Table 5. Reported Mitigation Efforts Adopted by Mexican Citizens to Protect Against H1N1 in Mexico

Mitigation Activity	Mexico City (n=837)	San Luis Potosi (n=951)	Queretaro (n=878)
Frequently washing hands with soap/water	89.3	81.1	76.1
Using a mask	63.4	64.7	50.0
Using hand sanitizer/gel	30.1	30.3	16.0
Covering cough/sneeze with tissue or elbow	21.5	14.1	24.0
Avoiding crowds/public gatherings	19.5	29.5	14.8
Ventilating the home	19.9	17.3	18.6
Avoiding shaking hands/kissing when greeting	11.7	16.1	11.9
Avoiding close contact with symptomatic people	10.4	11.4	8.6
Incidence of H1N1 at time of survey (per 100,000 inhabitants)	14.1	16.1	1.6

Note: Number of observations represents the number of households surveyed.
Source: Adapted from Table 2 in Aburto et al (2010).

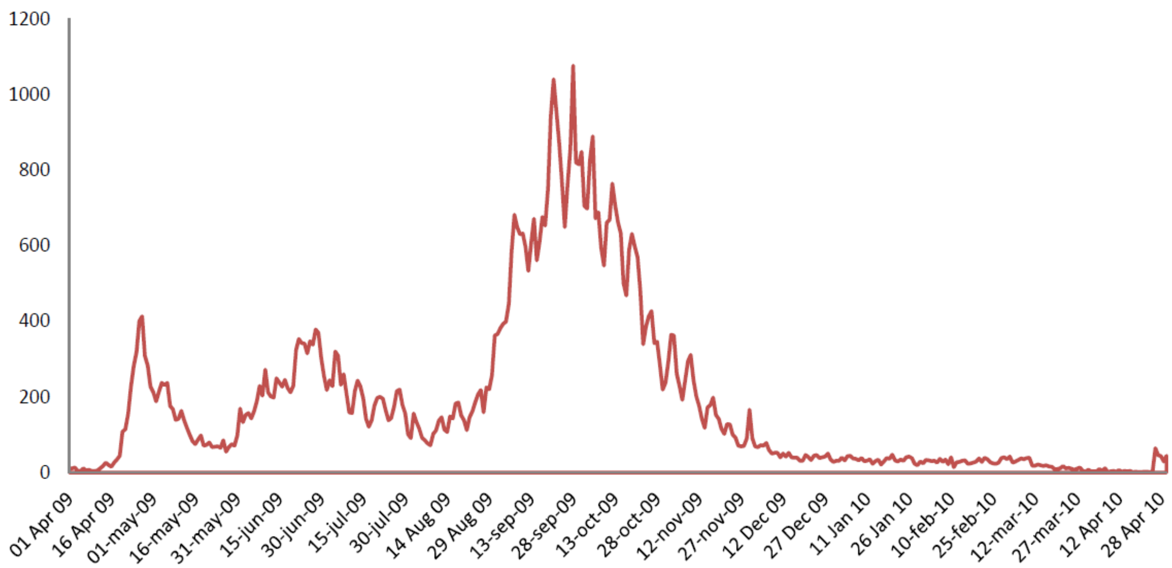
Table 6. Impact of H1N1 Prevalence on Diarrhea and Gastroenteritis from Infectious Origin (A09X) for Children Under 5 including controls for Government Expenditures

	Comparison group: 2008 vs.		
	Baseline Model	Baseline + State Expenditures in Health	Baseline + Control for State and Federal Expenditures in Health
	(1)	(2)	(3)
Panel A: All			
H1N1*Treat	-0.093***	-0.094***	-0.092***
	(0.03)	(0.03)	(0.03)
Mean	993	993	993
Panel B: Male			
H1N1*Treat	-0.063***	-0.063***	-0.062***
	(0.02)	(0.02)	(0.02)
Mean	566	566	566
Panel C: Female			
H1N1*Treat	-0.031**	-0.031**	-0.030**
	(0.01)	(0.01)	(0.01)
Mean	427	427	427

Notes: *** p<0.01, ** p<0.05, * p<0.1. Robust standard errors in parentheses. Standard errors are clustered at the state level. Outcome variable is number of hospital discharges where the initial diagnosis was International Classification of Diseases (ICD-10) code A09X (Diarrhea and Gastroenteritis from Infectious Origin). Each cell represents a separate regression. For all periods, the control period is 2008, and the treatment period is 2009. All regressions include time and state fixed effects.

Appendices

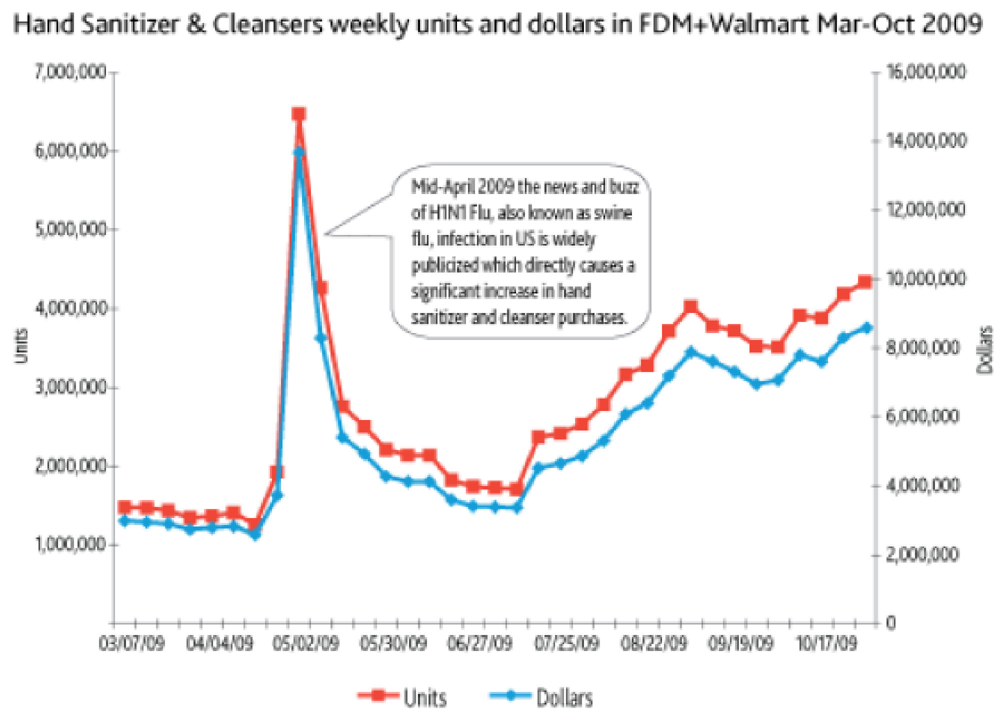
Appendix Figure A1. Distribution of Confirmed AH1N1 Cases in Mexico in 2009



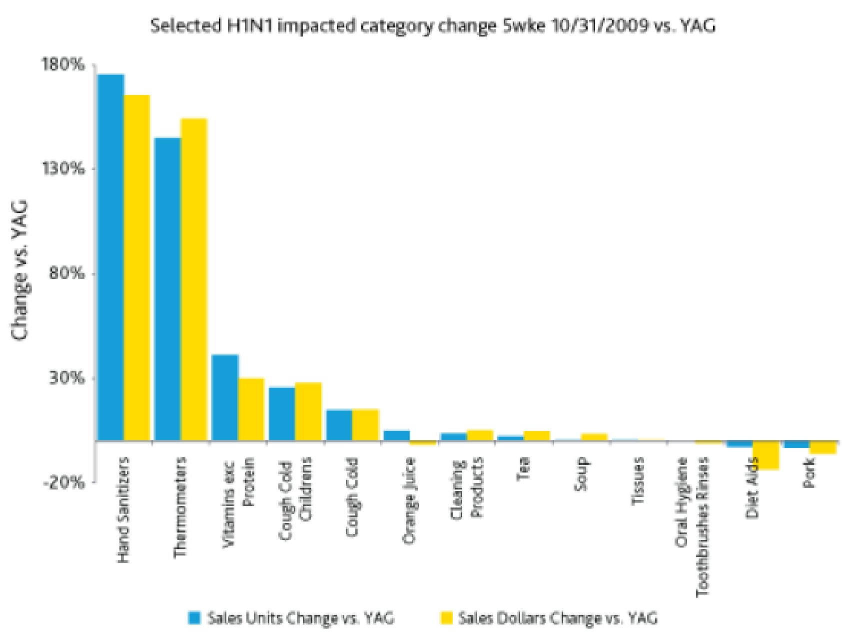
Source: Secretaria de Salud, "Panorama Epidemiologico de la Pandemia de Infuenza A(H1N1)-2009 en Mexico," June 2011. http://www.epidemiologia.salud.gob.mx/doctos/infoepid/publicaciones/2011/monografias/P_EPI_PANDEMIA_IFLUENZA_%20A_H1N1_2009_MEXICO.pdf.

Appendix Figure A2. Observed Consumer Behavior in the United States in 2009

Panel A. U.S. Consumer Purchases of Hand Sanitizers Increased in 2009

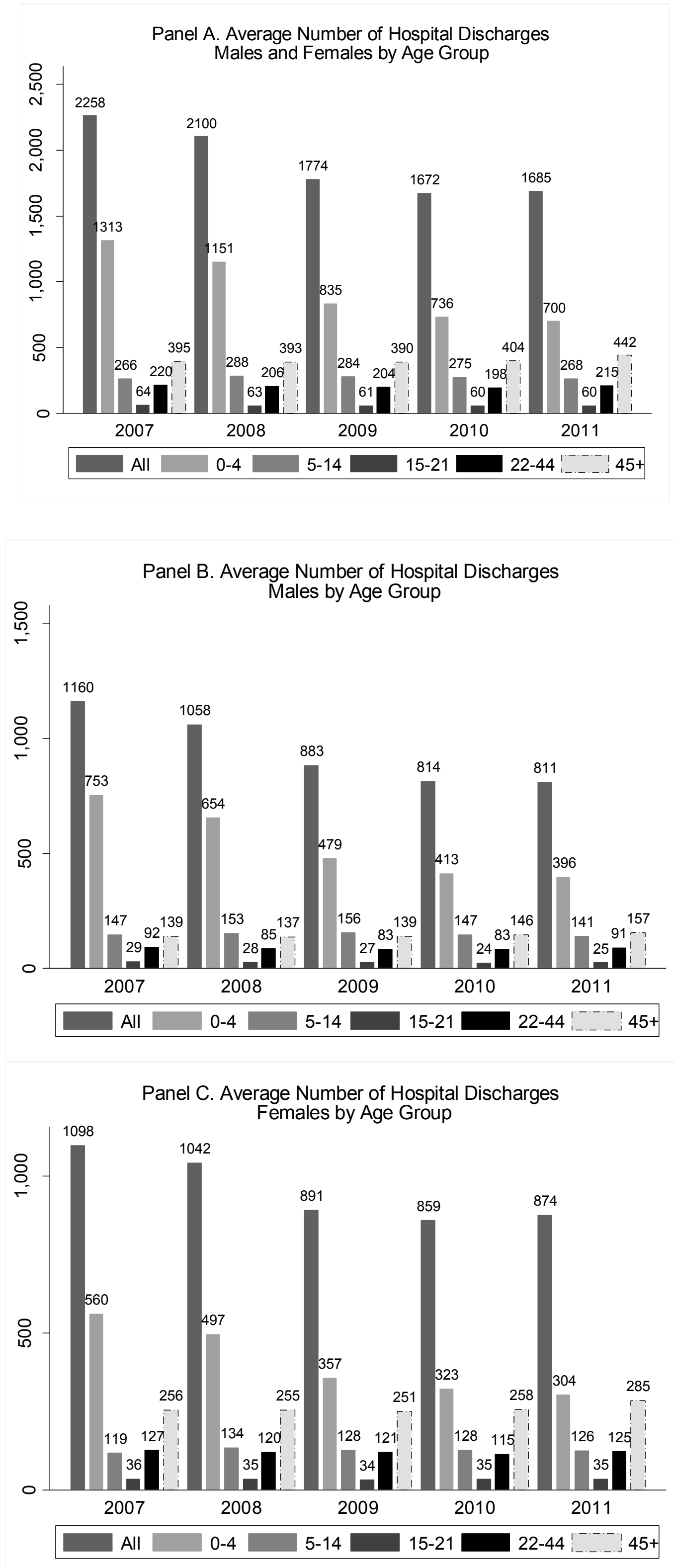


Panel B. U.S. Consumer Purchases of Other Preventive Products Also Increased in 2009



Source: The Nielsen Company, H1N1 Impact and Implications December 1, 2009, http://www.nielsen.com/us/en/newswire/2009/h1n1-impact-implications.html.

Appendix Figure A3. Average Number of Hospital Discharges in Mexico where Initial Diagnosis was Diarrhea and Gastroenteritis from Infectious Origin (A09X)



Appendix Table A1. Number of Calls to Hotline and Incidence of H1N1 by Wave and State, 2009

Spring Wave (Central Region)

	H1N1	Calls
Mexico City	7,032	648,205
Mexico	4,701	480,190
San Luis Potosi	4,589	71,503
Jalisco	4,047	223,184
Hidalgo	2,230	114,578
Guerrero	2,014	213,214
Puebla	1,733	172,240
Tlaxcala	1,606	6,162

Summer Wave (Southeast Region)

	H1N1	Calls
Chiapas	3,662	138,125
Yucatan	3,653	122,128
Veracruz	2,412	295,805
Oaxaca	2,385	92,742
Tabasco	1,306	81,619
Quintana Roo	738	99,035
Campeche	186	1,563

Fall Wave (Central and Northern Regions)

	H1N1	Calls
Nuevo Leon	4,037	285,538
Sonora	2,650	107,028
Tamaulipas	2,276	88,728
Baja California	1,734	51,777
Chihuahua	1,161	95,301
Coahuila	411	55,810

States Not classified by Chowell et al (2011)

	H1N	Calls		H1N1	Calls
Guanajuato	1,288	396,22	Michoacan	3,128	171,461
Colima	1,201	27,181	Queretaro	2,019	201,214
Zacatecas	973	5,487	Aguascalient	1,698	77,485
Baja California	945	24,463	Nayarit	1,671	3,416
Morelos	779	182,83	Durango	1,356	48,588
Sinaloa	619	8,744	Tamaulipas	2,276	88,728

Note: States in each wave as classified by Chowell et al (2011). Number of calls to hotline as reported by Secretaria de Salud (2010). Correlation coefficient between H1N1 and Calls is 0.40

Appendix Table A2: International Classification of Diseases, ICD-10

Outcome Measure	ICD-10	Description
Diarrhea and Gastroenteritis of Infectious Origin	A09X	A09X: Other gastroenteritis and colitis of infectious and unspecified origin, excludes: due to bacterial, protozoal, viral and other specified infectious agents (ICD-10 A00-A08); noninfective, e.g., neonatal.
Intestinal Infectious Excluding Diarrhea and Gastroenteritis of Infectious Origin	A00-A08	A00: Cholera A01: Thyphoid and parathyphoid fevers A02: Other salmonella infections (includes infection or foodborne intoxication due to any Salmonella species other than S. thypi and S. paratyphy A03: Shigellosis A04: Other bacterial intestinal infections, e.g., E-coli infection. A05: Other bacterial foodborne intoxications, not elsewhere classified, e.g., botulism. A06: Amoebiasis, e.g., acute and chronic amoebic dysentery, amoebic of intestine. A07: Other protozoal intestinal diseases, e.g., giardiasis, isosporiasis, balantidiasis. A08: Viral and other specificed intestinal infections (excludes influenza with involvment in gastroentestinal tract), e.g., rotaviral enteritis, adenoviral enteritis.
Acute Upper Respiratory Infections	J00-J06	J00: Acute nasopharyngitis (common cold) e.g., infection of sinus, excludes chronic sinusitis J01: Acute sinusitis J02: Acute pharyngitis, e.g., streptococcal sore throat, acute sore throat J03: Acute tonsillitis J04: Acute laryngitis and tracheitis J05: Acute obstructive laryngitis (croup) and epiglottitis J06: Acute upper respiratory infections of multiple and unspecified sites, e.g., acute laryngopharyngitis; excludes influenza virus
Injuries	S00-T98	S00-S09: Injuries to the head S10-S19: Injuries to the neck S20-S29: Injuries to the thorax S30-S39: Injuries to the abdomen, lower back, lumbar spine and pelvis S40-S49: Injuries to the shoulder and upper arm S50-S59: Injuries to the elbow and forearm S60-S69: Injuries to the wrist and hand S70-S79: Injuries to the hip and thigh S80-S89: Injuries to the knee and lower leg S90-S99: Injuries to the ankle and foot T00-T07: Injuries involving multiple body regions T08-T14: Injuries to unspecified part of trunk, limb or body region T15-T19: Effects of foreign body entering through natural orifice T20-T32: Burns and corrosions (of external body surface, confined to eye and internal organs, or of multiple and unspecified body regions) T33-T35: Frostbite T36-T50: Poisoning by drugs, medicaments and biological substances T51-T65: Toxic effects of substances chiefly nonmedicinal as to source T66-T78: Other and unspecified effects of external causes T79-T79: Certain early complications of trauma T80-T88: Complications of surgical and medical care, not elsewhere classified T90-T98: Sequelae of injuries, of poisoning and of other consequences of external causes

Source: International Statistical Classification of Diseases and Related Health Problems 10th Revision (ICD-10) Version for 2010, http://apps.who.int/classifications/icd10/browse/2010/en

Appendix Table A3. Summary Statistics on Average Number of Hospital Discharges Where the Initial Diagnosis was Diarrhea and Gastroenteritis from Infectious Origin (A09X)

	Ages					
Treatment Period	All	0-5	6-14	15-21	22-44	45+
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A. Average Number of Hospital Discharges where the Initial Diagnosis was Diarrhea and Gastroenteritis from Infectious Origin, *2008-2009*						
All						
	1937	993	286	62	205	392
	(1302)	(776)	(229)	(39)	(139)	(254)
Males						
	971	566	155	28	84	138
	(666)	(443)	(123)	(17)	(58)	(87)
Females						
	966	427	131	35	120	253
	(639)	(334)	(106)	(22)	(82)	(168)

Notes: Average number of hospital discharges where the initial diagnosis was diarrhea and gastroenteritis from infectious origin (International Classification of Diseases ICD-10 code A09X). Standard error in parentheses. Totals may not add up due to rounding.