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Who is that masked person: The use of face masks on Mexico City public transportation during the Influenza A (H1N1) outbreak

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ABSTRACT

This article examines three issues: (1) the use, *over time*, of facemasks in a public setting to prevent the spread of a respiratory disease for which the mortality rate is unknown; (2) the difference between the responses of male and female subjects in a public setting to unknown risks; and (3) the effectiveness of mandatory and voluntary public health measures in a public health emergency. The use of facemasks to prevent the spread of respiratory diseases in a public setting is controversial. At the height of the influenza epidemic in Mexico City in the spring of 2009, the federal government of Mexico recommended that passengers on public transport use facemasks to prevent contagion. The Mexico City government made the use of facemasks mandatory for bus and taxi drivers, but enforcement procedures differed for these two categories. Using an evidence-based approach, we collected data on the use of facemasks over a 2-week period. In the specific context of the Mexico City influenza outbreak, these data showed mask usage rates mimicked the course of the epidemic and gender difference in compliance rates among metro passengers. Moreover, there was not a significant difference in compliance with mandatory and voluntary public health measures where the effect of the mandatory measures was diminished by insufficiently severe penalties, the lack of market forces to create compliance incentives and sufficient political influence to diminish enforcement. Voluntary compliance was diminished by lack of trust in the government.

1. Introduction

This article examines three issues: (1) the use, *over time*, of facemasks in a public setting to prevent the spread of a respiratory disease for which the mortality rate is unknown; (2) the difference between the responses of male and female subjects in a public setting to unknown risks; and (3) the effectiveness of mandatory and voluntary public health measures in a public health emergency. We analyze these three issues in the context of facemask usage on public transportation in Mexico City in April/May 2009 during a 2-week period. In response to the influenza A (H1N1) pandemic, the federal government of Mexico recommended that passengers on public transport use facemasks. The Mexico City government made the use of facemasks mandatory for bus and taxi drivers, but enforcement procedures differed for these two categories. Over time, mask usage diminished for all subjects. Increases and decreases in mask usage mimicked the course of the influenza outbreak. Male and female metro passengers exhibited a significant difference in mask usage. There was not a significant difference in compliance with mandatory and voluntary public health measures. However, there

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was a significant difference in compliance with mandatory measures between bus and taxi drivers. We analyze these results in this article.

2. Literature on mask use to prevent the spread of influenza-like illness

There is very little literature on the use of facemasks to prevent the spread of influenza-like illness (ILI) in any setting. Our study is the only one to examine the use of facemasks to prevent the spread of ILI in a public setting during a public health emergency in which voluntary or mandatory mask usage formed a part of the emergency public health measures that were taken.

Jefferson et al. [1] conducted a systemic review of the literature of the use of facemasks in the presence of infectious diseases. Without exception, all the studies they reviewed had been conducted in hospital settings, not public settings.

The literature on the use of facemasks in the context of influenza is very sparse. MacIntyre et al. [24] conducted a study in 2005 and 2006 in household settings, rather than public settings. It was a prospective cluster-randomized trial comparing the use of surgical masks with no mask usage to prevent ILI in households. They chose 286 adults from 143 households who had been exposed to a child with clinical respiratory illness. They found that adherence to mask use significantly reduced the risk for ILI-associated infection. However, less than half of participants wore masks most of the time.

There is only one study of the effectiveness of mask usage in preventing the spread of seasonal influenza among healthy subjects in a public setting. Aiello et al. [2] examined whether use of facemasks reduces the incidence of ILI symptoms among young adults. They used a randomized trial during the 2007 influenza season. Participants ($N = 1417$) living in seven randomized university residence halls were assigned to one of two intervention groups or a control group. At the start of the influenza season, halls were randomly assigned to 6 weeks of mask use alone, mask and hand hygiene or control, and followed for incidence of ILI. In the group that used facemasks and hand hygiene and the group that used facemasks only, the protective effect increased over time compared to the control group. By week 4, the group that used only facemasks showed a 29% lower rate of ILI than the control group (95% CI: 3–47%). The group that used facemasks and hand hygiene had a 26% lower rate than the control group (95% CI: 0–45%), adjusted for covariates. The rate of infection continued to decrease over time in the groups that used facemasks. After 6 weeks, the group that used only facemasks experienced a 45% lower infection rate compared to the control group (95% CI: 6–67%). The group that used facemasks and hand hygiene experienced a 41% lower infection rate compared to the control group (95% CI: 1–65%). This study suggests that mask use was associated with a reduction in the rate of ILI from 29% to 45%.

On 3 May 2009, 10 days into Mexico's response to the Influenza A (H1N1) outbreak, the World Health Organization issued interim guidance on the use of masks in the community setting in Influenza A (H1N1) outbreaks [3]. This WHO document first notes that the main route of human-to-human transmission of the new Influenza A (H1N1) virus appears to be via respiratory droplets, which are expelled by speaking, sneezing or coughing. It then notes that any person who is within approximately 1 m from someone who has influenza-like symptoms is at risk of being exposed to potentially infective respiratory droplets. The WHO cites a study that suggests that the use of masks could reduce the transmission of influenza in health-care settings [1].

The WHO guidance indicates that the benefits of wearing facemasks have not been established in the community setting, especially in open areas, but notes that many individuals may wish to wear facemasks in the home or community setting. Using a facemask can enable an individual with influenza-like symptoms to cover their mouth and nose to help contain respiratory droplets. However, using a facemask incorrectly may increase the risk of transmission. The interim guidance concludes that, if facemasks are to be used, this measure should be combined with other general measures to help prevent the human-to-human transmission of influenza, training on the correct use of facemasks and consideration of cultural and personal values.

In contrast, the 2005 WHO Guidelines for communicating with the public during an outbreak describe wearing facemasks during disease outbreaks as an example of extreme behaviors that cause social disruption out of proportion to the true severity of the risk [4].

3. The Mexican context

Mexico was prepared for an influenza pandemic 3 years before the A (H1N1) influenza pandemic occurred [5]. Mexico's pandemic preparation plan envisaged three types of measures: (1) medical interventions (antiviral medication, vaccines, medical attention and personal protection equipment); (2) non-medical interventions (personal hygiene, e.g. hand-washing), travel restrictions, quarantine, social distancing (e.g. school closures) and communication of risks); and (3) the maintenance of social and economic systems, prioritizing security and legislation, water and food supplies, energy supplies, transportation, telecommunications and financial services [6].

Mexico's pandemic preparations and its response to influenza A (H1N1) were based on cutting edge intelligence and close cooperation with the world's most advanced economies. Mexico is the *only developing country member* of the Global Health Security Action Group, a public health communications network whose other members are Canada, Japan, the United States and several European countries. Studies of earlier pandemics (including the 1918–1919 influenza pandemic and the 2003 SARS epidemic) had convinced the Mexican government and the other members of the group that the benefits of pandemic planning exceeded the costs.

The Mexican government knew that a flu pandemic could infect 25–35% of population. A model based on past pandemics predicted the following probable impact of a worst-case-scenario pandemic in Mexico, assuming a duration of 8 weeks peaking in the 5th week, 25% of the population infected and 17% with a high risk of

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complications: 21,522–117,461 deaths; 80,727–352,513 hospitalizations; 11,798,789–20,710,591 medical consultations; 278% use of hospital capacity in the first week and 912% in the 5th week; 58% use of ventilator capacity in the first week and 269% in the 5th; 9,084.7 million MXN (672.9 million USD at 13.5) in direct costs and 148,853.8 million MXN (11,026.2 million USD) in indirect costs (1.6% of annual GDP) [6].

Mexico implemented its pandemic plan almost to the letter when the new A (H1N1) influenza virus was confirmed on April 23. The WHO declared a public health emergency of international concern on April 25 and raised its pandemic alert level to level 4 (April 27), level 5 (April 29) and level 6 (June 11). Mexico never imposed travel restrictions or quarantine, since both the CDC and WHO had determined that containment was not feasible and that efforts should focus on mitigation [7].

On April 23 at 11 p.m., the Federal Government of Mexico called a news conference. The Secretary of Health announced that there was a new strain of influenza in Mexico City and three states. By a Presidential Decree, all classes were cancelled in all educational institutions in Mexico City and the neighboring state of Mexico from April 24 (see Fig. 1). Greater Mexico City has a population of about 25 million.

On April 24, people started wearing facemasks in Mexico City. On April 26, the President of Mexico advised citizens to use facemasks on public transport and to avoid crowded places, in addition to advice to wash hands frequently, to cover mouths when coughing, to sneeze into the crook of the arm or a tissue and to avoid sharing food. These recommendations were repeated daily in press conferences and media advertisements. The Mexican army distributed 6 million masks, handing many out at subway stations and Metrobus lines [7].

On April 29, the Mexico City government began to require that drivers in the public transportation system wear masks and gloves. The mayor of Mexico City announced this public order in a press conference. The fine imposed for not complying was 40 times the daily minimum wage (around US$150). Instead of imposing those fines, Mexico City police enforced this regulation by extracting bribes from drivers who failed to comply and threatening to seize taxis for 5 days for non-compliance (information obtained from interviews with the bus and taxi drivers).

On April 30, a survey of 410 Mexico City adults revealed that 50% believed facemasks are somewhat or very effective in preventing infection and 50% believed they were mostly or completely ineffective [8]. Nevertheless, many members of the public were alarmed by the dramatic measures implemented by Mexico in response to the epidemic. The federal and Mexico City governments had progressively implemented social distancing: school closures (Mexico City April 24 and country-wide April 27); cancellation of public events (April 25); advising people wear facemasks and to avoid crowded, enclosed places (April 26); ordering all restaurants, bars, cantinas, party salons, gyms, cinemas and art galleries to close (April 28); requiring drivers in public transportation system to wear masks and gloves (April 29); and suspending all non-essential economic activities (May 1–5, announced April 29). Mexico City lowered its alert level from red to orange May 4 and to yellow May 6.

4. Method

From April 27 to May 9, we observed the use of facemasks in two metro stations in south of Mexico City. Men and women were observed between 9 a.m. and 11 a.m. daily. Every day, in each station, we observed 100 consecutive people entering and 100 exiting the metro to see if they were using facemasks.The Center for Disease Control (CDC) defines the term “facemask” as follows:

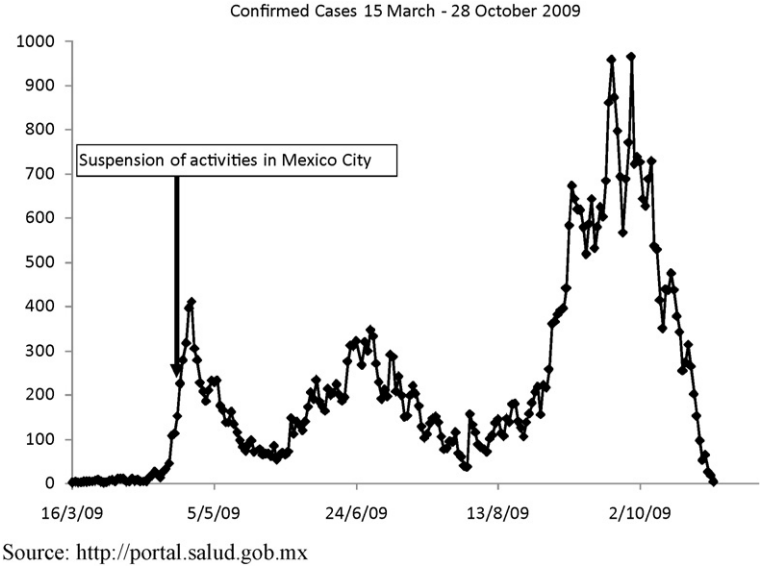

Fig. 1. Confirmed cases in Mexico.

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The term facemasks refers to disposable facemasks cleared by the U.S. Food and Drug Administration (FDA) for use as medical devices. This includes facemasks labeled as surgical, dental, medical procedure, isolation, or laser masks. Such facemasks have several designs. One type is affixed to the head with two ties, conforms to the face with the aid of a flexible adjustment for the nose bridge, and may be flat/pleated or duck-billed in shape. Another type of facemask is pre-molded, adheres to the head with a single elastic band, and has a flexible adjustment for the nose bridge. A third type is flat/pleated and affixes to the head with ear loops [9].

The CDC also defines the term "facemasks cleared by the U.S. FDA":

Facemasks cleared by the FDA for use as medical devices have been determined to have specific levels of protection from penetration of blood and body fluids. Facemasks help stop droplets from being spread by the person wearing them. They also keep splashes or sprays from reaching the mouth and nose of the person wearing the facemask. They are not designed to protect against breathing in very small particle aerosols that may contain viruses. Facemasks should be used once and then thrown away in the trash [9].

The facemasks we observed are exclusively one of the three types defined by the CDC. The type of facemasks used by at least 99% was the type commonly called "facemask" or "surgical masks" (http://www.pandemicflu.gov/vaccine/mask.html). The rest were N95 respirators. The masks handed out by the government to the general population were facemasks.

We noted the proportion of people using facemasks. Each day a sample of 400 passengers was observed for a total sample size of 5200 over the course of 13 days. The numbers of males and females are reported in Table 1. We also collected data on daily mask usage by bus drivers and taxi drivers between April 26 and May 9. Each day, we observed 100 buses and 200 taxis with a total of 1400 buses and 2800 taxis. All taxi and bus drivers were males. In no case were the subjects asked any questions. The use of the facemasks was simply observed and recorded.

The method used has the potential weakness that it did not include a random sample of the entire population. Hence, we cannot generalize our conclusions for the entire population. We did not ask any direct question. Thus, we cannot conclude the *reasons* behind wearing the masks.

5. The results

The increases and decreases in facemask usage mimicked the course of the epidemic. Facemask usage reached its peak for female metro passengers April 28, for male metro passengers on April 29, for bus drivers April 29–30 and for taxi drivers April 30. The peak in facemask usage roughly coincides with the severity of public health measures that were announced.

Table 1 shows us the results for male and female facemask usage. For every single day, the usage of facemasks among women was consistently higher than men. We performed a *t*-test for each day during the entire period. Assuming separate variance, we tested for equality of means between males and females for April 27: difference in means = −0.122 with 99% CI = −0.252 to 0.008 with a $t = -2.429$ and a p-value = 0.016. The p-values were not significantly different on 30th April, 1st May, 3rd May, 5th May, 7th and 9th May 2009. For all other days, they were significantly different.

Table 1
Summary statistics for males and females.

Date	Group	*N*	Proportion wearing masks	Standard deviation
April 27	Males	258	0.554	0.498
	Females	142	0.676	0.470
April 28	Males	251	0.550	0.499
	Females	149	0.765	0.425
April 29	Males	239	0.611	0.489
	Females	161	0.671	0.471
April 30	Males	232	0.401	0.491
	Females	168	0.488	0.501
May 1	Males	231	0.312	0.464
	Females	169	0.527	0.501
May 2	Males	222	0.288	0.454
	Females	178	0.331	0.472
May 3	Males	260	0.292	0.456
	Females	140	0.386	0.489
May 4	Males	272	0.242	0.429
	Females	128	0.290	0.455
May 5	Males	231	0.242	0.429
	Females	169	0.314	0.465
May 6	Males	273	0.299	0.475
	Females	127	0.341	0.460
May 7	Males	242	0.252	0.435
	Females	158	0.253	0.436
May 8	Males	236	0.205	0.461
	Females	164	0.201	0.366
May 9	Males	236	0.089	0.421
	Females	164	0.153	0.422

The results for the bus and the taxi drivers are shown in Fig. 2. It clearly shows the effect of the enforcement of the new regulation. For the first 5 days (April 26–30), the difference in the behavior of the taxi drivers and the bus drivers was not statistically significant (using *t*-test at 1% level of significance). However, from May 1 to May 6, the behavior of the bus drivers was significantly different (again at 1% level of significance using a *t*-test).

6. Discussion

The announcement on April 29 that all non-essential economic activity would cease May 1–5 was the high point in terms of the severity of public health measures that were announced. The height of facemask usage coincided with the announcement of the measures, rather than their implementation. This result underlines the importance of effective communication strategies during a public health crisis.

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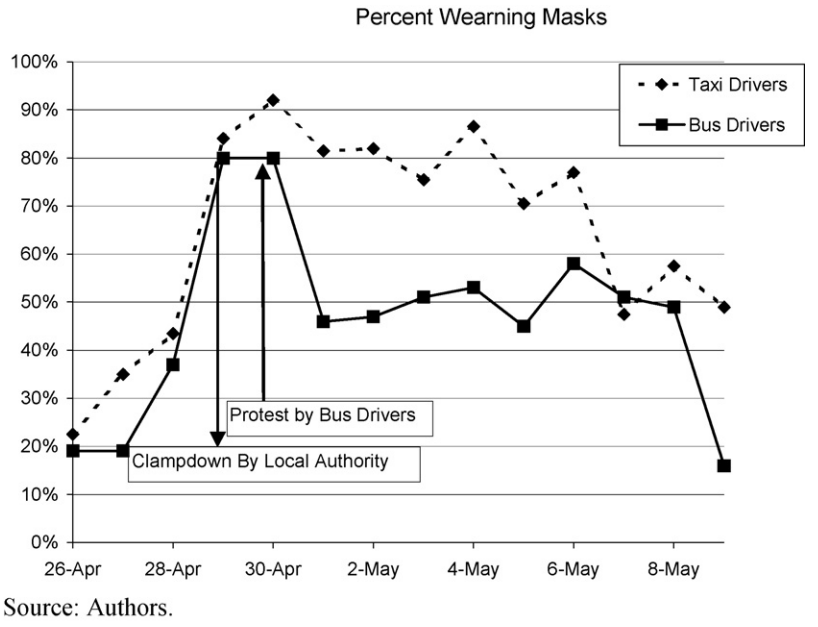

Fig. 2. Percent of bus and taxi drivers wearing masks.

The higher mask usage among women than among men is consistent with studies that show higher rates of risk taking among men than among women. A number of studies have found that males are more apt to take risks than females. For example, Campbell [10] shows that in the situations of conflict, men show more aggression. More aggressive car driving behavior among males than females has been documented in the literature ([11,12]). Sex difference features prominently in accident risk [13], drug-taking [14], gambling and financial decisions ([15,16]) and outdoor activities [17]. Psychological studies have found that females find risky situations more stressful [18]. There are other studies that show how some activities indirectly affect the risk of death from homicide [19]. Gender-based differences in risk taking have been documented in the context of crossing the road, catching a bus and other everyday activities [20]. Ours is the first study to examine gender-based differences risk taking behavior in everyday activities in relation to health risks from infectious disease epidemics.

The foregoing studies and our study suggest that gender-based differences in risk taking behavior may be the result of evolutionary psychology. That is, women have evolved to take fewer risks than men in order to preserve their ability to raise offspring and thereby perpetuate their own genes. Men have evolved to take greater risks because they must do so to attract mates and thereby propagate their own genes. Men had to engage in the risky activities of hunting and defense in order to care for their mates and offspring. Archer [21] examined sex difference in aggression in a large number of real world settings. He theorizes that such behavior is consistent with an evolutionary perspective.

While taxi drivers risked seizure of their vehicles for non-compliance, bus drivers did not. The taxi drivers' business was severely reduced during the outbreak and people hailing taxis in the street preferred taxi drivers wearing masks. Stronger penalties for non-compliance, together with consumer preferences, created stronger economic incentives for taxi drivers to wear masks. In addition, bus drivers staged a political protest against the mask requirements, while the taxi drivers did not.

For both groups of individuals (the taxi drivers and bus drivers group and the group of men and women), the use of masks peaked around April 29–30. Fig. 1 shows that the peak of infection occurred around April 29, 2009 with data updated from May 29, 2009. According to MMWR [22] published on April 30, 2009, the peak of the infections occurred during April 22–24. Thus, there is a 5–7-day difference between what was suspected and what actually occurred. This means that Mexico did not have a significant lag in getting the population mobilized both for voluntary usage of masks by men and women in the Metro or for the compulsory use of masks by the taxi and bus drivers. Looking back, the peak use of masks coincided with the peak infection.

7. Conclusions

In the context of a developing country, the supply of readily available means for community protection is limited. Criticism regarding the Mexican government's response ignores the complexity of recognizing and responding to an unexpected public health emergency [23]. In Mexico, supplies of masks were quickly exhausted during the A (H1N1) outbreak. Moreover, many governments in developing countries do not enjoy the population's trust. In Mexico, half the people did not believe, or follow, the President's recommendations regarding mask usage. Under such settings, mobilizing the population against

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Table 2a
Comparison of mask use between bus drivers and subway passengers on May 1.

Group	*N*	Proportion wearing masks	Standard deviation
Bus drivers	100	0.460	0.501
Subway passengers	400	0.438	0.497

Difference in means = 0.022 with 99% CI = −0.123 to 0.168 with a $t = 0.402$ and a p-value = 0.688. CI stands for confidence interval.

Table 2b
Comparison of mask use between bus drivers and subway passengers on May 2.

Group	*N*	Proportion wearing masks	Standard deviation
Bus drivers	100	0.470	0.502
Subway passengers	400	0.402	0.491

Difference in means = 0.068 with 99.00% CI = −0.078 to 0.213 with a $t = 1.209$ and a p-value = 0.229. CI stands for confidence interval.

pandemics is difficult in the best of times. This result is borne out by our study. There is also a clear gender difference in compliance, which is consistent with studies regarding gender-based responses to risk.

Differences in the severity of penalties, the effect of consumer preferences and political influence produced a significant divergence in compliance between bus and taxi drivers. Mandatory mask requirements increased compliance in bus and taxi drivers compared to metro passengers, who faced voluntary recommendations. Public perception regarding the effectiveness of the recommended measures strongly influenced compliance with voluntary recommendations. Indeed, there was not a significant difference between metro passengers and bus drivers on May 1 and May 2 (see Tables 2a and 2b). Thus, there was not a significant difference in compliance with mandatory and voluntary public health measures where the effect of the mandatory measures was diminished by insufficiently severe penalties, the lack of market forces to create compliance incentives and sufficient political influence to diminish enforcement, and the voluntary compliance was diminished by lack of trust in the government.

The conditions that allowed us to conduct this unique experiment – a sudden public health emergency in a city of 25 million in the face of an epidemic of unknown mortality – are unlikely to be repeated in the foreseeable future. Fig. 1 attests to this assertion. To wit, up to the end of October of 2009, Mexico had experienced three distinct waves of this epidemic. The third wave in September 2009 brought a peak that was unprecedented in Mexico. Yet, in September, no health emergency was declared—no public transport worker was asked to wear a facemask. Taxi drivers were not forced to wear them either. There was no public official exhorting the general population to wear facemasks. As a result, there was hardly anybody riding the subway wearing facemasks.

Competing interest

None.

Conflicts of interest

The views expressed here do not reflect the views of the institutions with which the authors are affiliated.

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