

This article was downloaded by: [Rutgers University], [Meng Li]

On: 07 July 2011, At: 10:15

Publisher: Routledge

Informa Ltd Registered in England and Wales Registered Number: 1072954 Registered office: Mortimer House, 37-41 Mortimer Street, London W1T 3JH, UK

## Psychology & Health

Publication details, including instructions for authors and subscription information:

<http://www.tandfonline.com/loi/gpsh20>

### Who got vaccinated against H1N1 pandemic influenza? - A longitudinal study in four US cities

Meng Li <sup>a</sup>, Gretchen B. Chapman <sup>a</sup>, Yoko Ibuka <sup>b</sup>, Lauren Ancel Meyers <sup>c</sup> & Alison Galvani <sup>b</sup>

<sup>a</sup> Department of Psychology, School of Arts & Sciences, Rutgers University, 152 Frelinghuysen Road, Piscataway, NJ 08854-8020, USA

<sup>b</sup> Department of Epidemiology and Public Health, School of Medicine, Yale University, 35 College Street, P.O. Box 208034, New Haven, Connecticut 06520-8034, USA

<sup>c</sup> Section of Integrative Biology and Santa Fe Institute, University of Texas at Austin, 1 University Station, C0930, Austin, TX 78712, USA

Available online: 1 January 2011

To cite this article: Meng Li, Gretchen B. Chapman, Yoko Ibuka, Lauren Ancel Meyers & Alison Galvani (2011): Who got vaccinated against H1N1 pandemic influenza? - A longitudinal study in four US cities, *Psychology & Health*, DOI:10.1080/08870446.2011.554833

To link to this article: <http://dx.doi.org/10.1080/08870446.2011.554833>



PLEASE SCROLL DOWN FOR ARTICLE

Full terms and conditions of use: <http://www.tandfonline.com/page/terms-and-conditions>

This article may be used for research, teaching and private study purposes. Any substantial or systematic reproduction, re-distribution, re-selling, loan, sub-licensing, systematic supply or distribution in any form to anyone is expressly forbidden.

The publisher does not give any warranty express or implied or make any representation that the contents will be complete or accurate or up to date. The accuracy of any instructions, formulae and drug doses should be independently verified with primary

sources. The publisher shall not be liable for any loss, actions, claims, proceedings, demand or costs or damages whatsoever or howsoever caused arising directly or indirectly in connection with or arising out of the use of this material.

## Who got vaccinated against H1N1 pandemic influenza? – A longitudinal study in four US cities

Meng Li<sup>a\*</sup>, Gretchen B. Chapman<sup>a</sup>, Yoko Ibuka<sup>b</sup>, Lauren Ancel Meyers<sup>c</sup>  
and Alison Galvani<sup>b</sup>

<sup>a</sup>*Department of Psychology, School of Arts & Sciences, Rutgers University,  
152 Frelinghuysen Road, Piscataway NJ 08854-8020, USA;* <sup>b</sup>*Department of Epidemiology  
and Public Health, School of Medicine, Yale University, 35 College Street,  
P.O. Box 208034, New Haven, Connecticut 06520-8034, USA;*

<sup>c</sup>*Section of Integrative Biology and Santa Fe Institute, University of Texas at Austin,  
1 University Station, C0930, Austin, TX 78712, USA*

(Received 31 August 2010; final version received 11 January 2011)

The recent H1N1 pandemic influenza stimulated numerous studies into the attitudes and intentions about the H1N1 vaccine. However, no study has investigated prospective predictors of vaccination behaviour. We conducted a two-wave longitudinal study among residents in four US cities during the course of the H1N1 outbreak, using Internet surveys to assess demographic, cognitive and emotional predictors of H1N1 vaccination behaviour. Surveys were conducted at two time points, before (Time 1) and after (Time 2) the H1N1 vaccine was widely available to the public. Results show that Time 2 vaccination rates, but not Time 1 vaccination intentions, tracked H1N1 prevalence across the four cities. Receipt of seasonal influenza vaccine in the previous year, worry, compliance with recommended interventions, household size and education assessed at Time 1 were significant prospective predictors of vaccination behaviour. Perception of the H1N1 vaccine, social influence and prioritised vaccine recipient status assessed at Time 2 also predicted vaccination behaviour. Critically, worry about H1N1 mediated the effects of both objective risk (prevalence at the city level) and perceived risk on vaccination behaviour. These results suggest that H1N1 vaccination behaviour appropriately reflected objective risk across regions, and worry acted as the mechanism by which vaccination behaviour followed objective risk.

**Keywords:** vaccination; H1N1; longitudinal

### Introduction

Predicting health behaviour is an important goal of health psychology. The 2009 H1N1 influenza outbreak illustrated the importance of anticipating behaviours that affect disease transmission. The outbreak started on 23 April 2009 in Mexico City, and rapidly spread to over 100 countries, causing the World Health Organisation

---

\*Corresponding author. Email: [mli@rci.rutgers.edu](mailto:mli@rci.rutgers.edu)

(WHO) to declare it a global pandemic on 11 June. A vaccine against H1N1 became available in the US in October 2009, and was offered to high-risk groups first, before enough doses were available to offer it to the general public. Because vaccination is one of the most effective ways to control a pandemic, it is crucial to understand factors influencing the public's vaccination behaviour under such situations.

Recent investigations into H1N1 vaccine acceptance have reported the public's attitudes and perceptions towards the vaccine, as well as predictors of vaccination *intention* (Chor et al., 2009; Eastwood, Durrheim, Jones, & Butler, 2010; Lau et al., 2009; Maurer, Harris, Parker, & Lurie, 2009; Seale et al., 2010; Wong & Sam, 2010). Predictors of vaccination *behaviour* have been examined in the context of seasonal influenza vaccination (e.g. Chapman & Coups, 1999, 2006), but not yet in the context of 2009 H1N1. Because the intention to vaccinate does not necessarily lead to vaccination, and vaccination behaviour for the 2009 H1N1 pandemic influenza may differ from that of seasonal influenza, a familiar and yearly occurrence, one cannot simply assume that predictors of 2009 H1N1 vaccination intentions will predict H1N1 vaccination behaviour. However, no previous study has identified longitudinal predictors of actual vaccination for the 2009 H1N1 influenza pandemic. This study does just that. The potential predictors investigated in the study include attitudes, perceptions and emotions about H1N1, as well as demographic variables, all measured months before actual vaccination behaviour.

Traditional theories related to preventive health behaviours emphasise the analysis of perceived costs and benefits of actions, for example, the health belief model (Becker, 1974; Janz & Becker, 1984; Leventhal, Hochbaum, & Rosenstock, 1960), protection motivation theory (Maddux & Rogers, 1983; Prentice-Dunn & Rogers, 1986), theory of reasoned action (Ajzen & Fishbein, 1980; Fishbein & Ajzen, 1975) and theory of planned behaviour (Ajzen, 1985; Ajzen & Madden, 1986). However, human behaviours are motivated not only by careful assessments of costs and benefits, but also by other factors such as emotions, habits, social influences and situational constraints. These influences are not only true for individual behaviours, but also for public behaviours such as vaccination, which affects other individuals. Recent inquiries into seasonal influenza vaccination have identified emotions, such as worry and anticipated regret, as mediating factors of the relationship between perceived risk and vaccination (Chapman & Coups, 2006). Studies on H1N1 influenza have also examined worry and anxiety (Goodwin, Haque, Neto, & Myers, 2009; Jones & Salathe, 2009; Rubin, Amlôt, Page, & Wessely, 2009), but these studies were conducted before the H1N1 vaccine was available and thus did not examine worry as a predictor of vaccination behaviour. In this article, we focus on worry as a predictor of vaccination, and a potential mediator for the relationship between objective risk and vaccination behaviour in a novel pandemic: the 2009 H1N1 influenza.

Although previous studies have examined the relationship between perceived risk and vaccination behaviour (Brewer et al., 2007), and the concordance between perceived risk and actual risk (Hertwig, Pachur, & Kurzenhäuser, 2005; Lichtenstein, Slovic, Fischhoff, Layman, & Combs, 1978; Pulford & Colman, 1996; Rothman, Klein, & Weinstein, 1996), few studies have examined perceived risk and objective risk together as predictors of vaccination behaviour. This study addresses this question. The H1N1 influenza pandemic provides a unique opportunity to evaluate objective risk. One characteristic that distinguished the H1N1 influenza from the seasonal influenza is a drastic difference of prevalence across geographic areas. To

test whether perceived risk and vaccination behaviour across different regions track the different objective risk levels, we conducted the study in four cities in the US. These cities represent regions with different levels of H1N1 prevalence rates: Milwaukee, New York City, Los Angeles and Washington, DC, where Milwaukee was the area with the highest and Washington, DC was the area with the lowest prevalence (Figure 1a).

We conducted an Internet survey during the H1N1 influenza pandemic, using a longitudinal design with two time points. The Time 1 survey was conducted among participants from the above four cities, between July and October 2009, when H1N1 was still quite active but before the vaccine was available. For this assessment, we measured potential factors such as risk perceptions, worry and vaccination intentions. The Time 2 survey was conducted among the same group of participants in January 2010, when the H1N1 vaccine had been widely available to the public for a month or more, so that most participants who were going to get vaccinated would have already

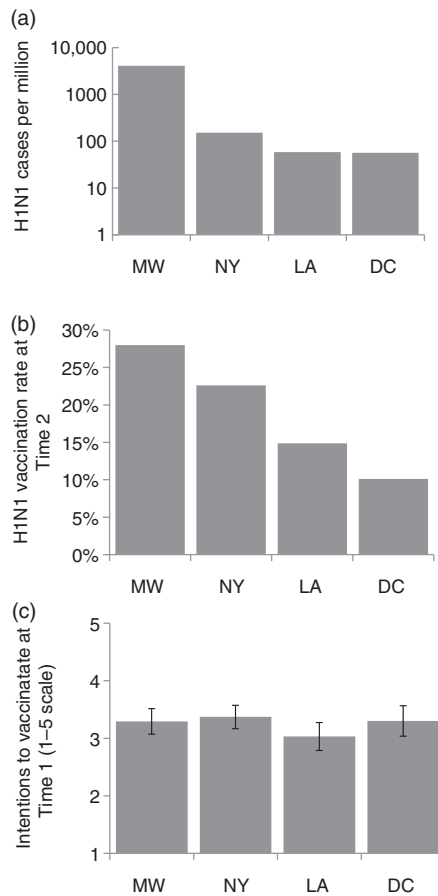


Figure 1. (a) H1N1 prevalence rates at Time 1 (prevalence calculated using cumulative confirmed cases as of 2 July 2009, extracted from Centers for Disease Control and state health departments by Research Triangle Institute, and population estimates by the United States Census Bureau, Population Division, 2009), (b) H1N1 vaccination rates at Time 2, and (c) H1N1 vaccination intentions at Time 1 among four cities: Milwaukee (MW), New York City (NY), Los Angeles (LA) and Washington, DC (DC). Error bars:  $\pm 2$  SEs.

done so (Center for Disease Control and Prevention, 2010). The most important measure in the second survey was whether participants had vaccinated against H1N1, but additional factors were also assessed, such as perceptions about the H1N1 vaccine and social influence on vaccination. These latter questions were impossible to address at the time of the first survey, when the vaccine and information about it was not yet available. Demographic information was also collected from the survey company that enrolled all participants.

## Methods

### *Participants*

Between 28 July and 3 October 2009 (Time 1), a commercial survey company (Survey Sampling International, SSI) by email contacted potential participants from four US cities (Milwaukee, New York City, Los Angeles, and Washington, DC) who had previously agreed to serve on an Internet survey panel and invited them to participate in an Internet survey about H1N1 influenza (referred to as 'Swine Flu' at that time). One thousand and seven respondents completed the first survey: 239 in New York, 252 in Los Angeles, 268 in Milwaukee, and 248 in Washington, DC. Approximately 100 participants were recruited each week, with 25 from each city. Sixty two percent of the participants were female. The age distribution of participants approximated (but was slightly older than) the US adult population (United States Census Bureau, 2000): 18% were 18–34 years old, 39% were 35–54 years old and 43% were 55 years old and above. The procedure for quota-restricted sample selection was the same as in Ibuka, Chapman, Meyers, Li, and Galvani (2010). Between 11 and 19 January 2010 (Time 2), all participants who completed the first survey received an invitation to participate in a follow-up survey, and 479 completed this second survey: 138 in New York, 123 in Los Angeles, 139 in Milwaukee and 89 in Washington, DC. Among the 479 respondents at Time 2, seven were excluded from the analysis because they indicated that they had been infected with H1N1 (making vaccination unnecessary), leaving 472 participants in the analysis. Demographic information for those who did and did not respond to the Time 2 survey is listed in Table 2 of the appendix. Specifically, Time 2 respondents were older, with higher education and household income, and more of them were white.

### *Questionnaire*

#### *First survey (Time 1)*

The first survey assessed the following potential predictors of H1N1 vaccination: Perception of H1N1 risk and severity, worry about H1N1, last year's seasonal influenza vaccination, intentions to comply with health intervention from various sources (12 items) and intention to vaccinate. Original survey questions are listed in the appendix.

#### *Second survey (Time 2)*

The second survey asked participants to report whether they had received the H1N1 vaccine, either nasal or injection form. Also included in the second survey were the following measures (see the appendix): Perceptions of the H1N1 vaccine (in terms of safety, effectiveness, risk and severity of side effects, for nasal and injection forms,

respectively; these items were combined to form a vaccine perception scale<sup>1</sup>); whether participants belonged to the high-risk groups prioritised for H1N1 vaccination; and social influence for H1N1 vaccination (perception of vaccination as a social norm, 7 items, as well as specific others' opinions on vaccination, 8 items, all of which were combined to form a social influence scale<sup>2</sup>).

### *Demographic information*

Participants' demographic information was provided by the survey company (SSI), which recorded all potential participants' zip codes (from which city of residence was extracted), age, number of household members (up to 6), gender, marital status, employment status, education and household income levels.

## **Results**

### *Vaccination rates by city*

Based on our survey at Time 2, the four cities varied significantly in the proportion of participants who had vaccinated by Time 2 (Figure 1b): 28% in Milwaukee, 23% in New York City, 15% in Los Angeles and 10% in Washington, DC,  $\chi^2(3, N=472)=13.14, p=0.004$ . Vaccination rate by city (Figure 1b) was in the same rank order as H1N1 prevalence by city (Figure 1a). To examine the effect of geography on vaccination further, we conducted logistic regression analysis using contrast city codes that reflect the different prevalence rates: Milwaukee versus the other three cities (MWvs3), New York versus Los Angeles and Washington, DC (NYvs2), and Los Angeles versus Washington, DC (LAvsDC). When these three city codes were entered simultaneously into a logistic regression predicting H1N1 vaccination, MWvs3 ( $B=0.78, SE B=0.26, p=0.002$ ) and NYvs2 ( $B=0.74, SE B=0.30, p=0.014$ ) remained significant, while LAvsDC was not significant ( $B=0.44, SE B=0.44, p=0.31, ns$ ). Thus, H1N1 vaccination rate differed significantly between Milwaukee and the other three cities, as well as between NY and LA/DC, but not between LA and DC. Interestingly, intentions to vaccinate, measured at Time 1, did not differ across the four cities among respondents of the Time 2 survey<sup>3</sup> (Figure 2),  $F(3,468)=1.76, \eta^2=0.01, p=0.15$ . This discrepancy illustrates the importance of assessing actual vaccination behaviour (even if via self report, see Mangtani, Shah, & Roberts, 2007) rather than intentions to vaccination.

### *Prospective predictors of vaccination*

To identify potential prospective predictors of vaccination, we first performed bivariate correlation analysis between H1N1 vaccination status at Time 2 and all items measured at Time 1, including demographic factors. Table 1 lists significant correlations between Time 1 survey items and Time 2 vaccination status, including: receipt of seasonal-influenza vaccine last year, perceived risk of self being infected with H1N1, perceived risk of encountering somebody infected with H1N1, anticipated change in risk over the next year, perceived severity of infection, worry, compliance with requested interventions, intentions to vaccinate and willingness to pay for vaccine. Demographic factors with significant correlations to Time 2 vaccination status include: marital status, household size, education level,

whereby married or with domestic partner, highly educated participants from large households were most likely to vaccinate. These results are similar to those from past research on seasonal influenza vaccination, which demonstrated that past vaccination behaviour, perception of seasonal influenza risk and severity, worry and intentions to vaccinate predict vaccination behaviour (Chapman & Coups, 1999, 2006).

To identify the unique predictive power of each variable listed above, we performed a logistic regression using Time 2 vaccination status as the dependent variable, and all above Time 1 and demographic correlates of vaccination, as well as contrast codes for city as predictor variables. To compare predictors of vaccination behaviour with predictors of vaccination intention, we conducted a parallel regression with the same set of predictor variables, but with Time 1 vaccination intention as the dependent variable. To make the two regressions comparable, we did not include vaccination intention or willingness to pay for vaccine as a predictor in the logistic regression on vaccination behaviour. (Three missing values on risk of self getting infected and two missing values on risk of encountering someone infected were substituted by the mean value of the variable.)

Entering all potential Time 1 and demographic predictors at the same time resulted in six significant factors in the logistic regression predicting vaccination behaviour (Table 1): the city code of Milwaukee versus the other three cities, seasonal influenza vaccination last year, worry, compliance with recommended interventions, household size and education. By contrast, significant predictors for vaccination intention did not include any city code, household size or education, but included two additional factors that do not predict vaccination behaviour: perceived

Table 1. Summary of regression, logistic regression, and bi-variate correlations for Time 1 and demographic predictors of H1N1 influenza vaccination intention (Time 1) and behavior (Time 2).

Predictor	Intention		Behaviour			Bi-variate $r$	
	$B$	$SE(B)$	$B$	$SE(B)$	OR	Intention	Behavior
MW vs. 3	-0.06	0.10	0.79*	0.30	2.21	0.02	0.13**
NY vs. 2	0.07	0.10	0.53	0.33	1.70	0.07	0.09*
LA vs. DC	0.02	0.13	0.77	0.48	2.16	0.08	0.02
Seasonal last year	0.82**	0.09	1.63**	0.29	5.11	0.47**	0.32***
Risk: self-infected	-0.44	0.25	0.95	0.74	2.58	0.20**	0.17***
Risk: encounter	0.37*	0.19	-0.32	0.58	0.72	0.23**	0.10*
Risk change	0.16**	0.06	0.08	0.19	1.09	0.24**	0.10*
Severity	0.07	0.04	-0.01	0.13	0.99	0.32**	0.13**
Worry	0.18**	0.05	0.33*	0.15	1.39	0.36**	0.18***
Compliance	0.86**	0.07	0.67**	0.25	1.96	0.60**	0.22***
Household size	0.00	0.04	0.34**	0.11	1.41	0.01	0.12**
Education	0.05	0.03	0.20*	0.09	1.22	0.09	0.09
Marital status	0.03	0.09	0.02	0.28	1.02	0.02	0.10*
Constant	-0.26	0.23	-6.83*				
Not in regression							
Vaccination intention							0.39
Log willingness to pay						0.43**	0.13**

Note: \* $p = 0.05$ ; \*\* $p < 0.01$ ; \*\*\* $p < 0.001$ .



risk for encountering someone with H1N1 and estimated risk change. These results support the use of vaccination behaviour, instead of intention, as the dependent variable in efforts to identify predictors of vaccination, as variables that predict vaccination intention do not necessarily predict actual vaccination.

### *Mediation between Time 1 risk perception and Time 2 vaccination*

Despite the significant simple correlation between the risk perception items and vaccination (Table 1), the above logistic regression for vaccination behaviour shows that risk perceptions did not predict H1N1 vaccination when other Time 1 and demographic measures were accounted for (Table 1). This finding indicates that the effect of risk perception on vaccination may be mediated by other variables included in the regression. Chapman and Coups (2006) found that emotions such as worry and anticipated regret mediate the relationship between risk perception and seasonal influenza vaccination. In our survey, worry may serve a similar mediating role, as it remained significant in the regression. In addition, compliance with recommended interventions, which remained significant in the regression, may also be a potential mediator, as higher risk perception may prompt people to act according to intervention messages that encourage H1N1 vaccination, leading to eventual vaccination behaviour.

To test these two potential mediators between participants' risk perception at Time 1 and their H1N1 vaccination status at Time 2, we conducted bootstrapping analyses, using methods described by Preacher and Hayes (2008) for estimating direct and indirect effects with multiple mediators. This approach has several advantages: it allows analysis with multiple mediators, accommodates dichotomous dependent variables, has a low type 1 error and does not assume normal sampling

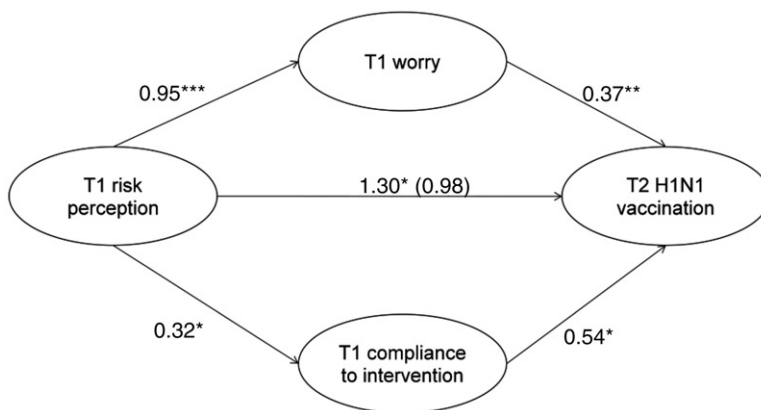


Figure 2. Mediation paths between Time 1 risk perception and Time 2 H1N1 vaccination status through worry and compliance to intervention measured at Time 1. Values in graph represent unstandardized regression coefficients. For path from risk perception to vaccination, the coefficient outside of parentheses represents total effect of risk perception on vaccination, while coefficient inside parentheses represents direct effect after mediators are included. Controlling variables (not shown) include: receipt of seasonal influenza vaccine last year, perception of severity, household size, education and marital status. \* $p < 0.05$ . \*\* $p < 0.01$ . \*\*\* $p < 0.001$ .

distribution (MacKinnon, Lockwood, & Williams, 2004; Preacher & Hayes, 2008; Shrout & Bolger, 2002). To choose a risk perception measure as the independent variable in the mediation analysis, we first conducted a logistic regression with all three risk perception measures predicting vaccination, and found risk of self getting infected emerged as the only significant risk predictor of vaccination ( $B=1.54$ ,  $p=0.02$ ), while risk of encountering someone with H1N1 ( $B=0.15$ ,  $p=0.77$ ) and risk change ( $B=0.22$ ,  $p=0.18$ ) were no longer significant predictors. Therefore, in the SPSS macro created by Preacher and Hayes (2008) for bootstrap analyses with multiple proposed mediators, risk of self getting infected was entered as the predictor variable, Time 2 H1N1 vaccination status was the dependent variable, and worry and compliance to intervention were proposed mediators, while seasonal vaccination last year, perception of severity and demographic factors (household size, education, marital status) were entered as controlling variables.<sup>4</sup>

Consistent with the logistic regression results, the bootstrapping results indicated that the total effect of risk perception on vaccination (total effect = 1.30,  $p=0.03$ ) became nonsignificant when worry and compliance to intervention were included in the regression model (direct effect of risk perception = 0.98, ns) (Figure 2). The analyses showed that the total indirect effect (i.e. the difference between the total and direct effects) of risk perception on vaccination through the two mediators was significant, with a point estimate of 0.52 and a 95% bias-corrected and accelerated bootstrap confidence interval (BCa CI; Efron, 1987) of 0.22 to 1.02 (which does not include zero). Thus, worry and compliance to intervention fully mediated the relationship between risk perception at Time 1 and H1N1 vaccination at Time 2. The specific indirect effects of each mediator showed that worry was a unique mediator, with a point estimate of 0.37 (95% BCa CI = 0.08–0.73), and so was compliance to intervention, with a point estimate of 0.18 (95% BCa CI = 0.02–0.48). In summary, worry and compliance to intervention measured at Time 1 fully mediated the effect of Time 1 risk perception on Time 2 H1N1 vaccination.

### *Vaccine-related predictors (Time 2) of vaccination*

We did not include any survey item about perceptions of the H1N1 vaccine in the Time 1 survey because at that time it was unclear if and when the vaccine would be available to the public, and no guidelines were available about its safety, effectiveness and appropriate recipient populations. However, perceptions about the vaccine could be critical predictors of vaccination behaviour, as safety and side-effect issues are particularly relevant to the newly developed H1N1 vaccine (Eastwood et al., 2010; Lau et al., 2009; Seale et al., 2010; Sypsa et al., 2009). Thus, we assessed perceptions of the H1N1 vaccine (safety, effectiveness, side effect risk and severity) and included measures of social influence on vaccination in the Time 2 survey. We also asked whether participants were in the high-risk group prioritised to receive the first batch of H1N1 vaccine, because the high-risk group may be particularly motivated to vaccinate. These items are listed in the appendix in the supplementary material available online.

We conducted a logistic regression (Table 2) including all significant predictors of vaccination among Time 1 survey and demographic items identified in the previous logistic regression on vaccination behaviour, as listed in Table 1, the contrast codes for city, as well as the three Time 2 vaccine-related variables: vaccine perception scale

Table 2. Summary of logistic regression analysis for Time 1, Time 2 and demographic variables predicting H1N1 influenza vaccination at Time 2.

Predictors of vaccination	<i>B</i>	SE( <i>B</i> )	OR	<i>b</i>
MW vs. 3	0.56	0.34	1.76	0.25
NY vs. 2	0.79*	0.40	2.20	0.33*
LA vs. DC	0.73	0.56	2.08	0.24
Seasonal vaccination last year	1.18***	0.33	3.25	0.58***
Worry	0.39*	0.16	1.47	0.40*
Compliance to intervention	-0.15	0.33	0.86	-0.09
Household size	0.37**	0.12	1.44	0.46**
Vaccine perception (T2)	1.51***	0.28	4.52	1.12***
Social influence (T2)	1.56***	0.28	4.77	1.00***
High-risk group status (T2)		0.35	3.12	0.47***
Constant	-4.55			-2.78

Notes: Logistic regression model  $\chi^2(10, N=472)=189.44, p<0.001$ . Percentage of participants vaccinated = 19.5%. OR = Odds ratio. *b* = regression weights for standardised predictors. Vaccine perception is a combined score of perceptions of vaccine safety, effectiveness, side effect risk and side effect severity. MW vs 3 contrasts Milwaukee with three other cities in the study. NY vs 2 contrasts New York City with Los Angeles and Washington, DC. LA vs DC contrasts Los Angeles and Washington, DC. Social influence is a combined score of the perceived social norm to vaccinate (7 items) and reported opinions of others about vaccination (eight items). High-risk group status coded as 1 for *yes*, 0 for *no* and 0.5 for *do not know* (2.3%). Other variables used same coding as in Table 1. \* $p<0.05$ ; \*\* $p<0.01$ ; \*\*\* $p<0.001$ .

(see section ‘Methods’), social influence scale (see section ‘Methods’) and high-risk group status. Our analysis shows that the three vaccine-related variables were all significant predictors of H1N1 vaccination, even after the effects of city, Time 1 and demographic predictors were controlled for (Table 2). Regression coefficients for the standardised predictors show that seasonal influenza vaccination last year is the greatest Time 1 predictor, whereas vaccine perception is the greatest Time 2 predictor of vaccination.

### ***Mediation of the city effect on vaccination***

City represents objective risk level in our study, especially the contrast between Milwaukee and the other three cities. As reported in the beginning of section ‘Results’, Milwaukee differed significantly in Time 2 vaccination rate compared to the other three cities. However, the logistic regression shown in Table 2 indicates that the effect of Milwaukee versus the other three cities was no longer significant after controlling for Time 1, Time 2 and demographic predictors of vaccination. This means that objective risk level, which predicted vaccination on its own, was no longer a significant predictor of vaccination after other predictors were controlled for, suggesting potential mediation in the effect of objective risk on vaccination. To identify mediators of the city effect, we first conducted contrast tests between Milwaukee and the other three cities on all Time 1, Time 2 and demographic predictors included in Table 2. Our results indicate that Time 1 worry (contrast value = 1.02,  $p=0.01$ ) was the only variable with significant contrast between

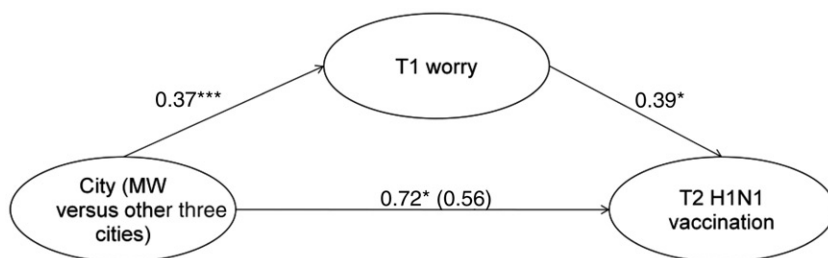


Figure 3. Mediation paths between City (MW versus the other three cities) and Time 2 H1N1 vaccination status through worry measured at Time 1. Values in graph represent unstandardised regression coefficients. For path from city to vaccination, the coefficient outside of parentheses represents total effect of risk perception on vaccination, while coefficient inside parentheses represents direct effect after mediators were included. Controlling variables (not shown) include: city codes NY versus LA and DC, LA versus DC, receipt of seasonal influenza vaccine last year, household size, compliance to intervention (Time 1), vaccine perception (Time 2), social influence (Time 2) and high-risk group status (Time 2). \* $p < 0.05$ . \*\*\* $p < 0.001$ .

Milwaukee and the other three cities, and thus, the only potential mediator of the city effect on vaccination.

Next, we directly tested worry as the potential mediator between city (Milwaukee versus the other three cities) and vaccination, using similar bootstrapping technique as described earlier (Preacher & Hayes, 2008). All other predictors in Table 2 were entered as controlling variables. We found that the total effect of city (MWvs3) on vaccination (total effect = 0.72,  $p = 0.03$ ) became nonsignificant when worry was included in the regression model (direct effect of city = 0.56, ns) (Figure 3). Further, the indirect effect of city on vaccination through worry was significant, with a point estimate of 0.15 (BCa CI = 0.02–0.35), indicating that worry was a significant full-mediator for the effect of city on vaccination, that is, the effect of objective risk level on vaccination.

Given the critical role of worry in the above mediation, we wondered how objective risk affected worry. Conceivably, objective risk may have influence perceived risk, which in turn influenced worry. To test this mediation, we conducted a series of regressions using the Baron and Kenny (1986) approach. First, City (MWvs3) was a significant predictor of perceived risk ( $B = 0.05$ ,  $SE = 0.02$ ,  $p < 0.05$ ). Second, City (MWvs3) was a significant predictor of worry ( $B = 0.35$ ,  $SE = 0.11$ ,  $p < 0.01$ ) when city was the only factor included in the regression, but its coefficient was reduced ( $B = 0.28$ ,  $SE = 0.11$ ,  $p < 0.01$ ) after perceived risk ( $B = 1.23$ ,  $SE = 0.22$ ,  $p < 0.001$ ) was also included in the regression, Sobel test  $Z = 2.25$ ,  $p < 0.05$ . Thus, perceived risk was a partial mediator for the relationship between City and worry.

## Discussion

This study revealed a number of interesting relationships among objective risk, subjective risk and vaccination against H1N1 influenza. Vaccination rates among our participants differed dramatically across the four cities, such that the vaccination

rate for Milwaukee participants was twice that of Washington, DC participants. This pattern of vaccination rates mirrors the incidence of H1N1 infections that these cities experienced in spring 2009. Thus, our results are consistent with the explanation that participants based their vaccination decisions in part on the objective risk of infection. However, various other features of the cities may have driven this pattern of vaccination rates, such as prior vaccination rates for seasonal influenza in the past. Therefore, we examined statistical mediators of the association between city and vaccination rates, and found that worry about H1N1, as assessed at Time 1, completely mediated the city effect, and no other mediators of vaccination were found. These results suggest that participants recognised their city-specific objective risk and experienced worry that was proportional to that risk. This worry in turn drove vaccination decisions.

Worry not only mediated the association between city (which represents objective risk) and vaccination, it also mediated the association between perceived risk and vaccination. This finding is analogous to that reported by Chapman and Coups (2006). Thus, vaccination decisions were quite sensitive to risk of infection, both objective risk and subjective risk, and such risk effects were mediated by worry about H1N1. These findings are consistent with those of previous research demonstrating that it is often the emotional aspect of risk that drives behaviour (Loewenstein, Weber, Hsee, & Welch, 2001). To the extent that worry tracks geographical objective risk, as it did in this study, basing vaccination decisions on worry, the emotional reaction of risk, may be quite adaptive.

This study also identified a number of other predictors of vaccination behaviour. Participants who had received a seasonal influenza shot the previous year were more likely to vaccinate against H1N1 influenza. Thus, individuals who are already generally inclined towards vaccinations, as indicated by previous behaviour, are more likely to adopt a new vaccine. At Time 1 we measured participant's willingness to comply with recommendations for health interventions that came from various sources, such as health authorities, family members or news media. Overall willingness to comply with recommendations predicted vaccination status at Time 2 and this compliance mediated the effect of perceived risk on vaccination status. Thus, participants who perceived greater risk were also more willing to comply with recommendations for action and were thus more willing to comply with the specific recommendation on vaccination issued months later.

Several factors assessed at Time 2 also predicted vaccination behaviour. Perceptions of safety and efficacy of the vaccine, membership in a high-risk group prioritised for vaccination, and perceived social norms to vaccinate all predicted vaccination behaviour. In addition, certain demographic groups were more likely to vaccinate. Being married or with domestic partner, having a higher education and larger household size all had significant simple correlations with vaccination behaviour. After controlling for other predictors (Table 1), larger household size was a unique predictor, consistent with a previous study (Ibuka et al., 2010).

The current findings have implications for how to boost vaccination rates during the next pandemic. We found that vaccination behaviour was sensitive to objective risk, which suggests that learning objective risk will allow individuals to act accordingly. Thus, as the main source of objective risk information for the public, the media and public health outreach campaigns should depict local objective risk accurately and specifically with regard to different regions. The effects of both objective risk and perceived risk on vaccination behaviour, however, were mediated

through worry, suggesting interventions that directly increase worry might be an effective means to encourage vaccination (Job, 1988; Witte & Allen, 2000). On the other hand, the effect of worry on vaccination also calls for caution against potential over-reaction among low-risk population, as their excessive worry may exhaust vaccine supplies reserved for populations under higher risk of infection, or lead to avoidance of economically important activities (Rubin, Potts, & Michie, 2010).

Vaccination was more likely among people who had previously received seasonal influenza shots, those from large households, and those in high-risk groups prioritised for vaccination. Targeting such individuals in vaccination campaigns may offer a high yield, and there may be less need for direct incentives to prompt vaccination among these individuals. Also, because of herd immunity, even vaccinating a portion of the population can reduce the size of the pandemic. Positive attitudes about the safety and efficacy of the vaccine were predictive of vaccination, consistent with previous research (Chapman & Coups, 1999). Social influence was also predictive of vaccination behaviour, which is consistent with previous work on the influence of social norms (i.e., Cialdini & Goldstein, 2004) and suggests that recent work employing social norms to change real world behaviour might be extended to vaccination (e.g. Schultz, Nolan, Cialdini, Goldstein, & Griskevicius, 2007).

This study also provides insight into basic psychological processes underlying health behaviour. Beyond social influence and situational constraints (such as priority status in receiving vaccine), vaccination behaviour in this study was surprisingly rational in that it tracked the objective risk on the city level. Vaccination behaviour also tracked perceived costs and benefits including perceived risk of infection and perceived safety and efficacy of the vaccine. Thus, participants made vaccination decisions as if they were maximising net benefit. Rational behaviour, however, was accomplished by way of emotional processing. Although previous studies have demonstrated the role of worry in the effects of *perceived* risk on vaccination behaviour (e.g. Chapman & Coups, 2006), this study demonstrated the role of worry in the effects of both *perceived* risk and *objective* risk on vaccination behaviour. Thus, worry, parallel to the cost and benefit assessments, acted as a critical emotional tool to direct people's vaccination behaviour.

Vaccination is critical in controlling disease spreading, and predicting vaccination behaviour involves assessing a specific set of factors that may be different from those predicting vaccination intentions. This study identified a set of prospective factors as well as concurrent factors of actual vaccination in regions of different prevalence levels, and highlighted the role of a specific emotion – worry – on vaccination. In future pandemics like the 2009 H1N1 influenza, successful vaccination campaigns may benefit from knowing what to look for in the effort to predict and promote vaccination behaviour.

### Acknowledgements

This research was supported by a collaborative NSF grant to the second, fourth and fifth authors. They thank the Models of Infectious Disease Agent Study (MIDAS) group, and especially Tonya Farris and Diane K. Wegener in the Research Triangle Institute for their help in obtaining and extracting H1N1 confirmed cases data from the Centers for Diseases Control and state health departments.

## Notes

1. A combined vaccine perception scale was created by first standardising each of the four vaccine perception items (score on each item was the mean response concerning the nasal and injection forms), reverse coding side effect risk and severity items, and then taking the mean (Cronbach's alpha = 0.74). Six missing values on this scale were substituted by the mean.
2. A combined social influence scale was created by taking the mean of standardised scores on the seven items on vaccination social norms and the eight items on others' opinions (Cronbach's alpha = 0.71 between the two means of social norm and others' opinion scores; an overall Cronbach's alpha was not used due to a substantial proportion of participants with at least one missing value). Ten missing values on social influence scale were substituted by the mean value.
3. This result is limited to respondents to Time 2 survey. When all participants at Time 1 were analysed, vaccination intentions did differ cross cities; however, the difference was only caused by low vaccination intentions among LA residents, and there was no difference among the other three cities in vaccination intention,  $F(2, 752) = 0.56$ ,  $\eta^2 = 0.01$ ,  $p = 0.57$ .
4. The city codes in the regression were not entered as controlling variables in the mediation analysis, because people's risk perception should be partly determined by the different objective H1N1 risk levels across the four cities. Indeed, contrast test confirmed that Milwaukee had significantly higher perceived risk of self getting infected compared to the other 3 cities,  $t(468) = 2.47$ ,  $p = 0.01$ . Given this difference in perceived risk across city, controlling for city would exclude a legitimate part of the variance in perceived risk from being tested in the mediation analysis.

## References

- Ajzen, I. (1985). From intentions to actions: A theory of planned behavior. In J. Kuhl & J. Beckman (Eds.), *Action-control: From cognition to behavior* (pp. 11–39). Heidelberg, Germany: Springer.
- Ajzen, I., & Fishbein, M. (1980). *Understanding attitudes and predicting social behavior*. Englewood Cliffs, NJ: Prentice-Hall.
- Ajzen, I., & Madden, T. (1986). Prediction of goal-directed behavior: Attitudes, intentions, and perceived behavioral control. *Journal of Experimental Social Psychology*, *22*, 453–474.
- Baron, R.M., & Kenny, D.A. (1986). The moderator-mediator variable distinction in social psychological research: Conceptual, strategic and statistical considerations. *Journal of Personality and Social Psychology*, *51*, 1173–1182.
- Becker, M. (Ed.) (1974). The health belief model and personal health behavior. *Health Education Monographs*, *2*, 324–473.
- Brewer, N.T., Chapman, G.B., Gibbons, F.X., Gerard, M., McCaul, K.D., & Weinstein, N.D. (2007). Meta-analysis of the relationship between risk perception and health behavior: The example of vaccination. *Health Psychology*, *26*, 136–145.
- Center for Disease Control and Prevention (2010). 2009 H1N1 Vaccine doses allocated, ordered, and shipped by project area. Retrieved from <http://www.cdc.gov/h1n1flu/vaccination/vaccinesupply.htm>
- Chapman, G.B., & Coups, E.J. (1999). Predictors of influenza vaccine acceptance among healthy adults. *Preventive Medicine*, *29*, 249–262.
- Chapman, G.B., & Coups, E.J. (2006). Emotions and preventive health behavior: Worry, regret, and preventive health behavior. *Health Psychology*, *25*, 82–90.
- Chor, J.S., Ngai, K.L., Goggins, W.B., Wong, M.C., Wong, S.Y., Lee, N., . . . , Chan, P.K.S. (2009). Willingness of Hong Kong healthcare workers to accept pre-pandemic influenza vaccination at different WHO alert levels: Two questionnaire surveys. *British Medical Journal*, *33*, b3391.

- Cialdini, R.B., & Goldstein, N.J. (2004). Social influence: compliance and conformity. *Annual Review of Psychology*, *55*, 591–621.
- Eastwood, K., Durrheim, D.N., Jones, A., & Butler, M. (2010). Acceptance of pandemic (H1N1) 2009 influenza vaccination by the Australian public. *Medical Journal Australia*, *192*, 33–36. Retrieved from [https://www.mja.com.au/public/issues/192\\_01\\_040110/eas11124\\_fm.pdf](https://www.mja.com.au/public/issues/192_01_040110/eas11124_fm.pdf)
- Efron, B. (1987). Better bootstrap confidence intervals. *Journal of the American Statistical Association*, *82*, 171–185.
- Fishbein, M., & Ajzen, I. (1975). *Belief, attitude, intention, and behavior: An introduction to theory and research*. Reading, MA: Addison-Wesley.
- Goodwin, R., Haque, S., Neto, F., & Myers, L.B. (2009). Initial psychological responses to Influenza A, H1N1 (“Swine flu”). *BMC Infectious Disease*, *9*, 166.
- Hertwig, R., Pachur, T., & Kurzenhäuser, S. (2005). Judgments of risk frequencies: Tests of possible cognitive mechanisms. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *31*, 621–642.
- Ibuka, Y., Chapman, G.B., Meyers, L.A., Li, M., & Galvani, A.P. (2010). The dynamics of risk perceptions and precautionary behavior in response to 2009 (H1N1) pandemic influenza. *BMC Infectious Diseases*, *10*, 296.
- Janz, N., & Becker, M. (1984). The health belief model: A decade later. *Health Education Quarterly*, *11*, 1–47.
- Jones, J.H., & Salathe, M. (2009). Early assessment of anxiety and behavioral response to novel swine-origin influenza A(H1N1). *PLoS One*, *4*, e8032.
- Job, R.F.S. (1988). Effective and ineffective use of fear in health promotion campaigns. *American Journal of Public Health*, *78*, 163–167.
- Lau, J.T., Yeung, N.C., Choi, K.C., Cheng, M.Y., Tsui, H.Y., & Griffiths, S. (2009). Acceptability of A/H1N1 vaccination during pandemic phase of influenza A/H1N1 in HongKong: Population based cross sectional survey. *British Medical Journal*, *339*, b4164.
- Leventhal, H., Hochbaum, G., & Rosenstock, I. (1960). *The impact of Asian influenza on community life: A study in five cities* (US Public Health Service Publication No. 766). Washington, DC: US Government Printing Office.
- Lichtenstein, S., Slovic, P., Fischhoff, B., Layman, M., & Combs, B. (1978). Judged frequency of lethal events. *Journal of Experimental Psychology: Human Learning and Memory*, *4*, 551–578.
- Loewenstein, G.F., Weber, E.U., Hsee, C.K., & Welch, N. (2001). Risk as feelings. *Psychological Bulletin*, *127*, 267–286.
- MacKinnon, D.P., Lockwood, C.M., & Williams, J. (2004). Confidence limits for the indirect effect: Distribution of the product and resampling methods. *Multivariate Behavioral Research*, *39*, 99–128.
- Maddux, J., & Rogers, R. (1983). Protection motivation and self-efficacy: A revised theory of fear appeals and attitude change. *Journal of Experimental Social Psychology*, *19*, 469–479.
- Mangtani, P., Shah, A., & Roberts, J.A. (2007). Validation of influenza and pneumococcal vaccine status in adults based on self-report. *Epidemiology and Infection*, *135*, 139–143.
- Maurer, J., Harris, K.M., Parker, A., & Lurie, N. (2009). Does receipt of seasonal influenza vaccine predict intention to receive novel H1N1 vaccine: Evidence from a nationally representative survey of US adults. *Vaccine*, *27*, 5732–5734.
- Preacher, K.J., & Hayes, A.F. (2008). Asymptotic and resampling strategies for assessing and comparing indirect effects in multiple mediator models. *Behavior Research Methods*, *40*, 879–891.
- Prentice-Dunn, S., & Rogers, R. (1986). Protection motivation theory and preventive health: Beyond the health belief model. *Health Education Research*, *1*, 153–161.
- Pulford, B., & Colman, A. (1996). Overconfidence, base rates and outcome positivity/negativity of predicted events. *British Journal of Psychology*, *87*, 431–445.



- Rothman, A.J., Klein, W.M., & Weinstein, N.D. (1996). Absolute and relative biases in estimations of personal risk. *Journal of Applied Social Psychology, 26*, 1213–1236.
- Rubin, G.J., Amlôt, R., Page, L., & Wessely, S. (2009). Public perceptions, anxiety, and behaviour change in relation to the swine flu outbreak: Cross sectional telephone survey. *British Medical Journal, 339*, 2651–2658.
- Rubin, G., Potts, H., & Michie, S. (2010). The impact of communications about swine flu (influenza A H1N1v) on public responses to the outbreak: Results from 36 national telephone surveys in the UK. *Health Technology Assessment, 14*, 183–266.
- Schultz, P.W., Nolan, J.M., Cialdini, R.B., Goldstein, N.J., & Griskevicius, V. (2007). The constructive, destructive, and reconstructive power of social norms. *Psychological Science, 18*, 429–434.
- Seale, H., Heywood, A.E., McLaws, M.L., Ward, K.F., Lowbridge, C.P., Van, D., & MacIntyre, C.R. (2010). Why do I need it? I am not at risk! Public perceptions towards the pandemic (H1N1) 2009 vaccine. *BMC Infectious Disease, 10*, 99.
- Shrout, P.E., & Bolger, N. (2002). Mediation in experimental and nonexperimental studies: New procedures and recommendations. *Psychological Methods, 7*, 422–445.
- Sypsa, V., Livanios, T., Psychogiou, M., Malliori, M., Tsiodras, S., Nikolakopoulos, I., & Hatzakis, A. (2009). Public perceptions in relation to intention to receive pandemic influenza vaccination in a random population sample: Evidence from a cross-sectional telephone survey. *Euro Surveillance, 14*, 19437. Retrieved from <http://www.eurosurveillance.org/ViewArticle.aspx?ArticleId=19437>
- United States Census Bureau (2000). Profile of General Demographic Characteristics. Retrieved from <http://censtats.census.gov/data/US/01000.pdf>
- United States Census Bureau, Population Division (2009). 2009 Population Estimates: Table 1: Annual Estimates of the Population for Incorporated Places Over 100,000, Ranked by July 1, 2009 Population: April 1, 2000 to July 1, 2009. Retrieved from <http://www.census.gov/popest/cities/tables/SUB-EST2009-01.csv>
- Witte, K., & Allen, M. (2000). A meta-analysis of fear appeals: Implications for effective public health campaigns. *Health Education and Behavior, 27*, 591–615.
- Wong, L.P., & Sam, I.-C. (2010). Factors influencing the uptake of 2009 H1N1 influenza vaccine in a multiethnic Asian population. *Vaccine, 28*, 4499–4505.