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# Do superstitious beliefs affect influenza vaccine uptake through shaping health beliefs?

Jiahui Lu [a,*], Meiyin Luo [a], Andrew Zi Han Yee [a], Anita Sheldenkar [a], Jerrald Lau [b], May Oo Lwin [a]

[a] Wee Kim Wee School of Communication and Information, Nanyang Technological University, Singapore
[b] Saw Swee Hock School of Public Health, National University of Singapore, Singapore

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ABSTRACT

*Background:* This study examined the impact of superstitious beliefs on influenza vaccine uptake and investigated the role of health beliefs as underlying psychological mechanisms. It is hypothesized that superstitious beliefs predict greater perceived risks in influenza and vaccines, which in turn affect influenza vaccine uptake.

*Methods:* A cross-sectional survey of Singaporeans and Singapore Permanent Residents aged between 21 and 70 (N = 668) was conducted using computer-assisted telephone interviews. The survey covered beliefs in superstition, health beliefs in influenza and vaccines, and influenza vaccine uptake intention and behavior using the Health Belief Model. Path analysis was adopted to examine the hypothesized model.

*Results:* Approximately 60% of the sample had never obtained influenza vaccination. The path analysis found that superstitious beliefs significantly predicted higher perceived barriers and lower perceived benefits of vaccines, which in turn predicted a lower intention to take influenza vaccine in the next year and/or a lower probability of ever taking influenza vaccine. In contrast, superstitious beliefs predicted higher perceived susceptibility and severity of influenza that in turn predicted higher influenza vaccine uptake intention and/or probability. Examining demographic variables and past experience on influenza as control and confounding factors did not significantly affect the results.

*Conclusion:* The findings imply that beliefs in superstitions can have mixed effects on vaccine uptake and intention through shaping beliefs of the disease and vaccines. Significant implications in health education and persuasion on vaccine uptake are discussed.



## 1. Introduction

The World Health Organization (WHO) has called for a global increase in seasonal vaccine use to mitigate the burden of seasonal influenza, an infectious disease that severely affects some 3–5 million people and may be the cause of nearly 250,000 – 500,000 deaths worldwide [1]. However, adult vaccination rates in developed countries such as the USA, the UK, and Japan have been relatively low, ranging from approximately 30–40% [2,3]. In Singapore, although influenza vaccination (IV) is recommended for the general population, the uptake rate is equally low. A study of Singaporean adults aged 50 years and above from the National Health Surveillance Survey (NHSS) reported uptake rates at an alarmingly low 15.2% [4]. Various reasons have been proposed to explain these poor uptake rates worldwide, such as lack of confidence [5] and lack of access to vaccines [2].

The health belief model (HBM) has often been employed to better understand why people adopt disease prevention behaviors such as vaccination [6,7]. It posits that individuals will perform a prevention behavior when they place value on the potential threat of a disease (i.e., perceived high susceptibility to the threat and high severity of the threat), and expect achievable behaviors to avoid that threat (i.e., perceived high benefits but minimal barriers of performing the behaviors). Besides these, modifying factors such as demographic, sociopsychological, and structural variables are proposed to affect the individual's health beliefs and thus indirectly influence health prevention behaviors [8,9]. In the context of IV, evidence has supported that the four basic health belief constructs significantly predict IV uptake [10–12]. Also, systematic reviews of IV uptake through the lens of HBM found that high levels of perceived vaccine benefits and low levels of barriers to

* Corresponding author at: Wee Kim Wee School of Communication and Information, Nanyang Technological University, 31 Nanyang Link, Singapore 637718, Singapore.
*E-mail address:* jhlu@ntu.edu.sg (J. Lu).

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get the vaccine are the most influential factors affecting IV uptake decisions across different populations [13–15]. Nevertheless, these reviews, along with some theoretical criticisms [16], also suggest that while much research has investigated modifying factors such as demographic variables, there is a lack of research attention to personality and cultural factors that may affect health beliefs and shape health behaviors.

Among many personality and cultural factors, superstitious beliefs have been identified as a possible factor that may contribute to health prevention behaviors. Superstition is defined as a set of beliefs that particular actions can lead to particular outcomes based on mysterious forces rather than scientific knowledge [17,18]. As a result, superstitious individuals may consider potential health threats as unknown events controlled by external power and feel numb to take preventive strategies. For example, the belief that AIDS is the result of witchcraft is a common superstition in sub-Saharan Africa, and it has been found to predict less condom use during sexual intercourse [19]. Also, superstitious beliefs were found to be associated with risk-taking behaviors and neglect of safety measures among taxi drivers, such as driving at a higher speed and resting less during a long trip. This is because superstitious drivers tended to attribute accidents to factors outsides their control (e.g., bad state of roads, malediction) and would deny their accountability [20,21]. Though superstitious beliefs are likely associated with less uptake of prevention behaviors, there is also evidence suggesting that superstitious beliefs predict greater risk avoidance. For instance, death rates during the Ghost Festival month in Taiwan were found to be significantly lower than during the other months. This implies that people tended to avoid unnecessary risks at that period if they had the belief that the presence of ghosts could contribute to a higher risk of accidents [22].

Despite its potential role in health prevention, empirical research has not examined the predictive effect of superstitious beliefs on vaccine uptake, not to mention the psychological mechanisms underlying such an association. Nevertheless, there are theoretical grounds to assume that superstitious beliefs can predict related health beliefs which in turn predict vaccine uptake decisions. Theories suggest that superstitious beliefs are related to high perceived risks of uncertain events [23]. Individuals with a higher degree of superstitious beliefs tend to have an external and chance locus of control [18,23,24]. They are more likely to link adverse events to chance in uncertain situations, even when such an association may occur only once [25]. Research has found that superstitious beliefs are positively related to individual factors such as pessimism [24], and perceived risks in high uncertain situations such as ill health from foods that are genetically modified [26]. In the context of influenza and IV, the public generally do not have sufficient background knowledge about influenza and vaccination [27,28] and often rely on anecdotes and personal experience for health decisions [29]. The lack of knowledge and anecdotes of influenza and IV will likely form an uncertain situation, in which high superstition should be related to high perceived risks of both influenza and vaccines. Though it has been recently reported that superstitious beliefs are related to anti-vaccination attitudes [30], how superstitious beliefs are related to perception towards influenza is still unknown.

In sum, though existing evidence suggests that superstitious beliefs can be associated with vaccine uptake behaviors through health beliefs, there is no empirical support for these associations. The current study, therefore, seeks to address this gap by investigating the associations between superstitious beliefs and influenza vaccination (IV) uptake and intentions, as well as examining health beliefs as the underlying mechanisms.

## 2. Methods

### 2.1. Study design and population

A cross-sectional survey was conducted in Singapore between February and March 2017, using computer-assisted telephone interviews (CATI). Using 0.05 as the significant level, an expected effect size of $f^2 = 0.02$ for each single predictor, and statistical power at 0.95, the G*Power software recommended that 652 participants were needed. Based on that, we decided to recruit a total of 1000 participants, in case of potential invalid and incomplete questionnaires.

The CATI system was initially pre-loaded with the first four digits of more than 10,000 randomly selected telephone numbers that were purchased by the university. The remaining four digits were randomly generated using Microsoft Excel. Following this, the interviewers recruited participants using random digit dialing to ensure a comprehensive and representative sample of the Singapore population. Participants were eligible if they were Singaporean or Singapore Permanent Residents between the ages of 21 and 70. A maximum of eight calls could be attempted to a phone number with no answer. Phone numbers of offices/workplaces were excluded from the database.

The interviews were held predominantly in English, which is the main language in Singapore. Some interviews were conducted in Mandarin or Malay, which are the other two major spoken languages in the country, if the recipient could not communicate in English. The questions and possible answers were read out to the participants and their selected answers were entered into the system by the interviewers. All of the questions were highlighted as optional and no incentives were given. Interviewers were trained extensively beforehand to familiarize them with the questions and ensure they adhered to protocol. Multi-lingual interviewers were hired to ensure interviews could be conducted in Mandarin and Malay, with instructions for interviewers to transfer calls to an interviewer with the appropriate language skills if they could not communicate with the call recipient. Calls were also randomly audited to ensure interviewers were following standard protocol. Response rate 3 was calculated based on the American Association For Public Opinion Research (AAPOR) [31], which estimates the proportion of completed interviews over all possible eligible respondents.

### 2.2. Measures

The original measurement in English was translated into two additional language versions in Chinese and Malay using the common translation-back translation procedure. The survey was pilot tested to ensure the accuracy of translations. The measure of superstitious beliefs was adapted from Tobacyk's [32] superstition subscale based on the Singapore culture. Participants indicated their agreement on three common superstitions in Singapore on a Likert scale ranging from 1 "Strongly disagree" to 5 "Strongly agree": (1) The number '4' is unlucky, (2) if you break plates or other ceramics, you will have bad luck, (3) Having your bed facing a mirror will cause your soul to leave your body while sleeping. The scale is reliable, $\alpha = 0.71$.

Measurements of health beliefs relating to influenza and vaccines were derived and adapted from previous literature [33–35], and their Cronbach's alphas ($\alpha$) were calculated based on the present data. Perceived susceptibility of influenza was measured with three items ($\alpha = 0.77$): "I think I am at high risk of getting influenza", "My chances of getting influenza in the next few months are great", and "I am more likely than other people to get the flu". Perceived severity of influenza was measured with three items ($\alpha = 0.51$): "Influenza is a serious illness", "Getting influenza would

affect my ability to do my usual activities", and "I will be very sick if I get influenza". Perceived benefits of vaccines were measured with three items ($\alpha = 0.69$), "Vaccines are important for disease prevention", "Vaccines that have been approved by the ministry of health are safe", "Everyone should be vaccinated against preventable diseases". Perceived barriers of vaccines was measured with 5 items ($\alpha = 0.62$), "Vaccinations can do more harm than good", "The flu vaccine causes a person to get the flu", "I worry about side effects from the flu vaccine", "Healthy people do not need to get a flu vaccine", "Flu vaccines are unnecessary". All items were measured on a Likert scale ranging from 1 "Strongly disagree" to 5 "Strongly agree".

IV uptake was measured at both intentional and behavioral level [36]. At the intentional level, participants indicated "how likely are you to get vaccinated against influenza in the next year" on a Likert scale from 1 "Definitely won't" to 5 "Definitely will". At the behavioral level, participants indicated if they have ever had a flu vaccine before (1 = yes, 0 = no). In addition, history of influenza experience was also accessed by an item "Have you had influenza in the last 12 months?" Finally, demographic information such as age and gender was also requested.

### 2.3. Data analysis

We hypothesized that superstitious beliefs would predict health beliefs related to influenza and vaccines which in turn would predict IV intention and uptake history. The conceptual model is shown in Fig. 1. The model was tested in the path analysis. Path analysis is a method that can simultaneously examine patterns of relationships between variables and allow mediation analyses [37]. The variable measuring previous IV uptake was declared as a binary variable in the path analysis model. Demographic variables and experience on influenza were also included in the analysis model as potential modifying variables if these variables were associated with both health beliefs and outcome variables. The analysis was performed in *R* software with the package 'lavaan'.

### 2.4. Ethical considerations

Participants were informed about study details and provided verbal consent for the survey before the interview started. The survey was approved by the Institutional Review Board of the University.

## 3. Results

### 3.1. Sample characteristics

A total of 668 participants completed the interview of which 552 (82.6%) were interviewed in English, 108 (16.2%) in Chinese, and 8 (1.2%) in Malay. Overall, we called 12,978 numbers, of which 8144 numbers were ineligible, 2388 were numbers that did not yield participants but left us unsure of their eligibility, and 1778 were refusals. Taking into account the estimated eligible respondents, we calculated the AAPOR response rate to be 22.4%.

Table 1 summarizes the basic demographic information and characteristics of the sample. In particular, mean age of participants was 45.5 ($SD = 14.4$; Median = 48). The majority are Chinese (76.5%), married (62.6), living in public housing (Housing Development Board flats; 73.1%), and have more than 12 years of education (66.3%). The sample was representative of the Singapore population, based on national statistics from 2016 [38].

More than half of the participants have never had an IV (59.7%) and had not had influenza in the last 12 months (64.1%). Over three quarters (76.2%) of participants thought that it was unlikely that they would get vaccinated against influenza in the next year. In general, participants did not perceive influenza as susceptible (M = 2.40, $SD = 0.78$) or severe (M = 3.10, $SD = 0.73$). In addition, they did not perceive vaccines as very beneficial (M = 3.35, $SD = 0.75$) or did not perceive many barriers to taking IV (M = 2.68, $SD = 0.71$).

### 3.2. Correlations between variables

Table 2 shows correlations between superstitious beliefs, health beliefs, vaccine uptake outcomes, vaccine history, and demographic information. The level of superstitious beliefs was negatively associated with ever having taken IV ($r = -0.13$, $p = .001$) but not with intention for IV in the next year ($r = -0.04$, $p = .28$). As expected, the degree of superstitious beliefs was significantly related to the four health belief constructs. It was positively related to perceived susceptibility of influenza ($r = 0.09$, $p = .019$), perceived severity of influenza ($r = 0.09$, $p = .022$), and perceived barriers of vaccines ($r = 0.25$, $p < .001$), while negatively related to perceived benefits of vaccines ($r = -0.20$, $p < .001$).

As expected, the IV intention was significantly related to all four HBM constructs. It was positively related to perceived susceptibility of influenza ($r = 0.18$, $p < .001$), perceived severity of influenza ($r = 0.18$, $p < .001$), and perceived benefits of vaccines ($r = 0.25$, $p < .001$), while negatively related to perceived barriers of vaccines ($r = -0.32$, $p < .001$). In contrast, ever having taken IV was only significantly related to perceived severity of influenza ($r = 0.13$, $p = .001$), perceived benefits ($r = 0.21$, $p < .001$) and barriers of vaccines ($r = -0.34$, $p < .001$), but not perceived susceptibility of influenza ($r = 0.06$, $p = .16$).

As for demographic variables, participants who are young, male, with higher education, and had influenza in the last 12 months were more likely to have had a previous IV and were less likely to be superstitious. They were also more likely to perceive vaccines as beneficial and less likely to have barriers to getting vaccinated.

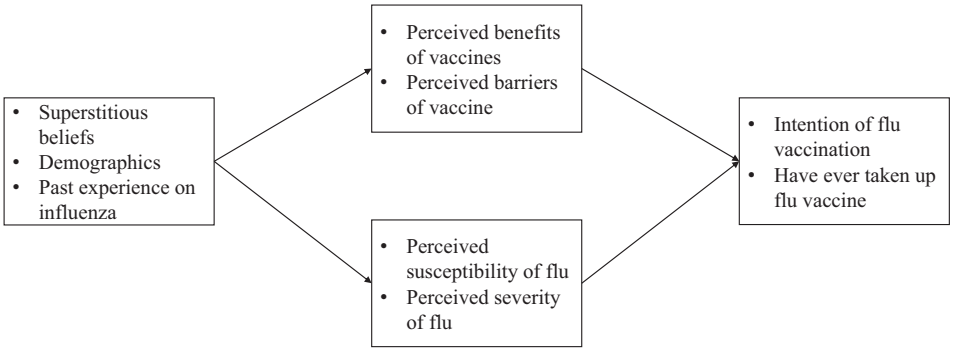


**Fig. 1.** The conceptual model of how superstitious beliefs affect influenza vaccine uptake and intention through shaping health beliefs.

**Table 1**
Demographics and characteristics.

| Demographic variables | | *n* | % |
|---|---|---|---|
| *Gender* | | | |
| | Male | 256 | 38.3 |
| | Female | 395 | 59.1 |
| | Missing data | 17 | 2.5 |
| *Age* | | | |
| | 21–30 | 150 | 22.5 |
| | 31–40 | 97 | 14.5 |
| | 41–50 | 148 | 22.2 |
| | 51–60 | 172 | 25.7 |
| | 61–70 | 101 | 15.1 |
| *Education* | | | |
| | GCE O/N level or below | 225 | 33.7 |
| | GCE A Level/Diploma or above | 194 | 66.3 |
| *Ethnicity* | | | |
| | Chinese | 511 | 76.5 |
| | Other | 24 | 23.5 |
| *Housing* | | | |
| | Public flats | 488 | 73.1 |
| | Others | 17 | 26.9 |
| *Marriage* | | | |
| | Married | 418 | 62.6 |
| | Not married | 26 | 37.3 |
| *Interview language* | | | |
| | English | 552 | 82.6 |
| | Chinese | 108 | 16.2 |
| | Malay | 8 | 1.2 |
| Characteristics | | *n* | % |
| *Have you had influenza in the last 12 months* | | | |
| | Yes | 240 | 35.9 |
| | No | 428 | 64.1 |
| *Have you ever had a flu vaccine* | | | |
| | Yes | 269 | 40.3 |
| | No | 399 | 59.7 |
| *How likely are you to get vaccinated against influenza in the next year?* | | | |
| | Definitely won't | 164 | 24.6 |
| | Probably won't | 184 | 27.5 |
| | Undecided | 161 | 24.1 |
| | Probably will | 76 | 11.4 |
| | Definitely will | 83 | 12.4 |
| | | Mean | *SD* |
| Perceived susceptibility of influenza | | 2.4 | 0.78 |
| Perceived severity of influenza | | 3.1 | 0.73 |
| Perceived benefit of vaccinations in general | | 3.35 | 0.75 |
| Perceived barriers of IV | | 2.68 | 0.71 |
| Superstition | | 1.78 | 0.72 |

Note. Total N = 668

### 3.3. Path analysis

As age, gender, education, and having influenza in the last 12 months were significantly related to health beliefs, IV uptake intention and behaviors, they were included in the path analysis as potential modifying factors. As the gender variable had only a small proportion of missing values, the listwise deletion was adopted in the path analysis, leading to a sample size of 651 being included in the analysis. The analysis revealed that the conceptual model showed a good fit, with $\chi^2(4) = 7.36$, $p = .118$, CFI = 0.994, TLI = 0.928, and RMSEA = 0.036 (See Supplementary Table S1 for the complete results of the analysis). A more parsimonious model was achieved by further removing non-significant paths, $\chi^2(22) = 32.03$, $p = .077$, CFI = 0.981, TLI = 0.961, and RMSEA = 0.026 (Fig. 2).

**Table 2**
Correlations between variables.

| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | IV intention | | | | | | | | | | | | | | | |
| 2 | IV uptake | 0.380*** | | | | | | | | | | | | | | |
| 3 | Superstition | −0.04 | −0.128*** | | | | | | | | | | | | | |
| 4 | Perceived susceptibility of influenza | 0.183*** | 0.06 | 0.090* | | | | | | | | | | | | |
| 5 | Perceived severity of influenza | 0.178*** | 0.132*** | 0.089* | 0.275*** | | | | | | | | | | | |
| 6 | Perceived benefits of vaccines | 0.252*** | 0.208*** | −0.198*** | −0.02 | 0.06 | | | | | | | | | | |
| 7 | Perceived barriers of vaccines | −0.316*** | −0.335*** | 0.254*** | 0.04 | 0.00 | −0.427*** | | | | | | | | | |
| 8 | Age | −0.02 | −0.117** | 0.109** | −0.128*** | 0.06 | −0.122** | 0.188*** | | | | | | | | |
| 9 | Gender (1 = male) [a] | 0.05 | 0.138*** | −0.083* | 0.00 | 0.01 | 0.114* | −0.200*** | −0.128*** | | | | | | | |
| 10 | Education (1 = A Level/Diploma or above) | 0.131*** | 0.198*** | −0.249*** | 0.00 | −0.04 | 0.155*** | −0.241*** | −0.431*** | 0.219*** | | | | | | |
| 11 | Ethnicity (1 = Chinese) | −0.03 | 0.07 | 0.086* | −0.04 | −0.03 | −0.01 | −0.01 | 0.086* | 0.08 | 0.01 | | | | | |
| 12 | Housing (1 = public flats) | −0.06 | −0.05 | 0.110** | 0.00 | −0.01 | −0.05 | 0.06 | −0.06 | −0.05 | −0.212*** | −0.07 | | | | |
| 13 | Marriage (1 = married) | 0.04 | −0.084* | 0.03 | −0.081* | 0.03 | 0.04 | 0.07 | 0.523*** | −0.06 | −0.165*** | −0.02 | −0.079* | | | |
| 14 | Resident state (1 = citizen) | 0.04 | 0.07 | −0.02 | −0.03 | −0.06 | −0.07 | 0.01 | 0.06 | 0.04 | −0.07 | 0.159** | −0.01 | −0.06 | | |
| 15 | Influenza in the last 12 months | 0.167*** | 0.117** | −0.088* | 0.251*** | 0.089* | 0.160*** | −0.120** | −0.120** | 0.092* | 0.197*** | 0.02 | −0.05 | −0.02 | 0.03 | |

Note. N = 668.
* $p < .05$; ** $p < .01$; *** $p < .001$.
[a] For gender, N = 651 due to missing values.

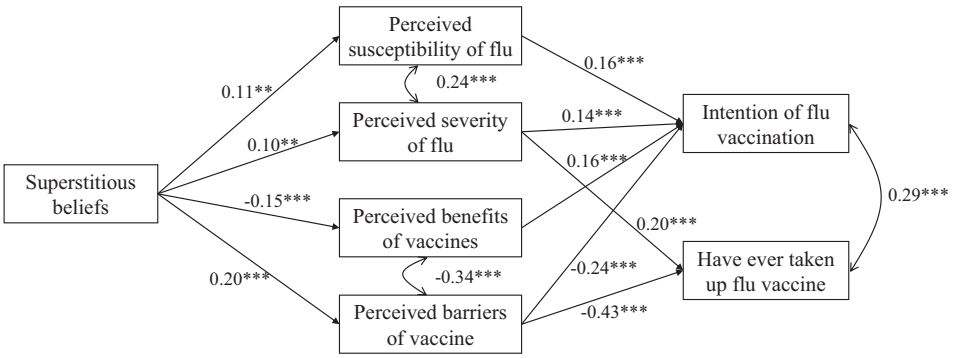


**Fig. 2.** The parsimonious model in path analysis for the relationship between superstitious beliefs, health beliefs, and influenza vaccine uptake and intention. *Note*: Values reported are standardized path coefficients. Age, gender, education, and having influenza in the last 12 months were included in the analysis while they were not displayed in the figure. Model fit: $\chi^2(22) = 32.03$, $p = .077$, CFI = 0.981, TLI = 0.961, and RMSEA = 0.026. **, $p < .01$; ***, $p < .001$. For intention of flu vaccination, $R^2 = 0.19$; for having ever taken up flu vaccine, $R^2 = 0.25$.

The path analysis suggests that superstitious beliefs significantly predicted greater perceived risks of both influenza and IV which in turn affected IV intention and behavior, after controlling for demographic factors and experience of influenza. As for IV intention, superstitious beliefs showed two contrasting effects in predicting IV intention. While superstitious beliefs predicted lower IV intention through lower perceived benefits of vaccines (Indirect effect = −0.024, *SE* = 0.008, $p = .004$) and higher perceived barriers of vaccines (Indirect effect = −0.05, *SE* = 0.012, $p < .001$), they also predicted higher IV intention through higher perceived susceptibility (Indirect effect = 0.017, *SE* = 0.007, $p = .02$) and severity (Indirect effect = 0.02, *SE* = 0.009, $p = .031$) of influenza. As for ever having taken IV, the results were similar except that only perceived barriers of vaccines (Indirect effect = −0.087, *SE* = 0.019, $p < .001$) and perceived severity of influenza (Indirect effect = 0.02, *SE* = 0.009, $p = .031$) could significantly mediate the effects of superstitious beliefs on the outcome of ever having taken IV. These results suggest that superstitious beliefs can have contradicting effects on IV uptake and intention, and could help to explain why the level of superstitious beliefs was not associated with IV intention in general.

Though demographic variables and previous experience of influenza were controlled as modifying factors in the path analysis as suggested by the HBM, they can also be confounding variables of the effects of superstition on health beliefs and IV uptake. For example, the association between superstitious beliefs and perceived severity of influenza can result from the fact that they both associate with age, such that the elderly can have a higher level of superstitious beliefs and can also suffer more from influenza because of their decrease in immunity. In this case, superstitious beliefs may not have a true effect on the perceived severity of influenza. Therefore, in order to rule out potential confounding effects of demographic factors and previous experience of influenza, they were also examined as confounding factors by additionally estimating their predicted effects on superstitious beliefs in the model. The analysis yielded similar model fit indices to the previous one, $\chi^2(4) = 7.67$, $p = .11$, CFI = 0.994, TLI = 0.920, and RMSEA = 0.038 (See Supplementary Table S1). More importantly, the effects of superstitious beliefs on health beliefs, and those of health beliefs on IV uptake and intention remained significant. This finding suggests that superstitious beliefs do indeed have an effect on health beliefs and in turn affected IV intention and behavior.

## 4. Discussion

Our study set out to better understand how superstitious beliefs can influence people's intention to take up the influenza vaccine, by altering individuals' beliefs about influenza and vaccination. Though overall effect sizes were small, we found that superstitious beliefs indeed influenced perceived susceptibility and severity of influenza, as well as the perceived barriers and benefits of vaccines.

In line with previous research showing that superstitious beliefs are related to pessimism and increased perceived risks [24,26], superstitious beliefs were found to be associated with both the perceived susceptibility and severity of influenza, which were significant predictors of influenza vaccine uptake. In contrast, we found superstitious beliefs to be negatively associated with perceived benefits and positively associated with perceived barriers of vaccines. This finding is consistent with the recent evidence that superstitious beliefs are associated with negative vaccine attitudes [30]. It suggests that superstitious people think that vaccines have more negative effects than positive ones, resulting in them not taking up the influenza vaccine. Moreover, the effect of superstition on perceived barriers and benefits of vaccines are higher than its effect on perceived susceptibility and severity of influenza, suggesting that superstitious beliefs can have a net negative impact on influenza vaccine uptake.

One potential reason for this might be that our measure of superstitious belief has tapped mainly on negative superstition. Researchers have argued that negative superstitions are developed by anxious people with an external locus of control, in order to combat the amount of perceived uncertainty in their environment [39,40]. Negative superstitious beliefs are considered a maladaptive psychological mechanism to deal with the perceived loss of control, and possible lead to pessimistic beliefs about things one is uncertain about, such as contracting an illness, or taking up the influenza vaccine [24,41]. In other words, negative superstitious beliefs are associated with individuals who are more likely to think that negative things will happen to them. Our study supported such an assertion, as we found that negative superstitious beliefs were significantly associated with greater susceptibility and severity of influenza, as well as greater negative and lesser positive effects of vaccines on oneself.

In line with other studies, our study also validated aspects of the HBM in the context of Singapore, showing that perceived susceptibility and severity of illness, alongside perceived barriers and benefits of vaccines, were significantly associated with vaccine uptake [42,43]. Our study lends further empirical support for interventions targeting these beliefs about influenza vaccination.

Overall, our study holds several important theoretical and practical implications. To our knowledge, our study provides one of the first empirical investigations on the role that superstitious beliefs play in determining vaccine uptake. Using the HBM as a theoretical lens, we found that negative superstitions drive pessimism and

negative beliefs about vaccines and illnesses in general. Future research examining the theoretical drivers of vaccine uptake behavior should build on that theoretical knowledge, and take into account cultural-specific beliefs which include superstitions.

Regarding practical outcomes, our study offers support for interventions targeting vaccine uptake to address negative superstitious beliefs, in addition to more traditional target beliefs such as perceived susceptibility, severity, barriers, and benefits. With utmost care and cultural sensitivity, interventions to increase vaccine uptake can and should address perceived uncertainty that might prime someone to adopt a superstitious worldview, either through a better formulation of health messages, or through tackling the inherent pessimism of people who hold negative superstitious beliefs.

## 5. Limitations

There are several limitations in our study that needs to be taken account of. First, our theoretical model assumed causality among the variables. Although our study was based on sound theoretical foundations, the cross-sectional nature of our data meant that causality could not be established between the variables. Future research should attempt a longitudinal or experimental design to assess the causal assumption of the model.

Second, our measure of superstitious beliefs only reflected negative ones. As other researchers have noted [41], superstitious beliefs can be positively-valenced as well, with these positive superstitious beliefs (e.g., holding a lucky charm) being more psychologically adaptive rather than maladaptive. It is possible that positive superstitious beliefs might lead to a more optimistic, rather than pessimistic outlook on illnesses and vaccines. Future research should address these limitations by measuring both negative and positive beliefs of superstition.

Third, as the response rate was low in the current investigation, there might be potential bias from non-participation. Of those 1778 refusals, 1694 (95.3%) respondents expressed a direct rejection to participate in the survey because of personal reasons, and 81 respondents terminated in the mid of the interviews. Nevertheless, we were able to include a representative sample comparable to the Singapore population regarding age, gender, ethnicity, education, and housing. Future studies should consider factors affecting respondents' refusal in their study design.

Last, measures for perceived severity of influenza, perceived benefits, as well as perceived barriers of vaccines, were not optimally reliable statistically. This could be because the measures were adapted from previous studies originating in the West. Future research should utilize culturally-validated measures in order to increase their reliability, and attempt to replicate the findings of our study in order for the conclusions and findings to be read with more confidence. Despite these limitations, we believe our study has contributed to the understanding of the influence of superstitious beliefs on vaccine uptake.

## 6. Conclusion

Immunization through the administration of vaccines has long been acknowledged to be a cost-effective and crucial intervention of seasonal influenza in the general population. This study is the first to suggest that individuals' superstitious beliefs have mixed effects, with stronger negative effects, on the decision and intention of influenza vaccine uptake through shaping health beliefs in the disease and vaccines. Future vaccine persuasion should address the negative consequences of this worldview.

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## Conflict of interest

The authors declare they have no conflict of interests.

## Declaration of interest

None.

## Author contributions

Conceptualization: M.O.L., J. Lu, A.S., A.Y., J. Lau; Methodology: M.O.L., J. Lu, A.S., J. Lau; Analysis: J. Lu, M.L., A.Y., A.S., J. Lau; Writing-Original Draft Preparation, J. Lu, M.L., A.Y., A.S., J. Lau; Writing-Review & Editing, M.O.L., J. Lu, M.L., A.Y., A.S., J. Lau; Funding Acquisition: M.O.L. All authors have read and approved the manuscript.

## Appendix A. Supplementary material

Supplementary data to this article can be found online at https://doi.org/10.1016/j.vaccine.2019.01.017.

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