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## Economic evaluation of the vaccination program against seasonal and pandemic A/H1N1 influenza among customs officers in Greece

Maria Mamma, Demetrios A. Spandidos\*

Department of Virology, University of Crete School of Medicine, Heraklion, Greece

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### ABSTRACT

**Introduction:** Health policies from many countries recommend influenza vaccination of “high-priority” professional groups, including customs officers. Our aim was to estimate the economic impact of the vaccination program against influenza among customs officers in Greece during the 2009/2010 period.

**Materials and methods:** We developed a decision analytical computational simulation model including dynamic transmission elements that estimated the economic impact of various scenarios with different attack rates, symptomatic percentages and vaccination participation among customs officers. We also assessed in real-time the economic impact of the national 2009/2010 campaign against seasonal and pandemic A/H1N1 influenza.

**Results:** Implementing a seasonal and pandemic A/H1N1 influenza vaccination program among customs officers in Greece with a participation rate of 30%, influenza vaccination was not cost-saving in any of the studied influenza scenarios. When the participation rate reached 100%, the program was cost-saving, when the influenza attack rate was 30% and the symptomatic rate 65%. The real-time estimated mean net cost–benefit value in 2009/2010 period was –7.3 euros/custom officer.

**Conclusions:** With different clinical scenarios, providing a vaccination program against seasonal and pandemic A/H1N1 influenza can incur a substantial net benefit for customs offices. However, the size of the benefit strongly depends upon the attack rate of influenza, the symptomatic rate as well as the participation rate of the customs officers in the program.

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### 1. Introduction

Influenza, one of the most common infectious diseases in adulthood, has been associated with substantial morbidity and mortality [1]. Influenza infection leads to excess health care resource use due to physicians visits, hospitalizations, intensive care unit admissions and deaths in the general population, especially in adults over 65 years of age [2]. Among healthy working age

adults, the economic impact of influenza infection is associated with substantial work absenteeism, which leads to lost workplace productivity and excess physicians visits [3–5].

Vaccination remains the mainstay for the prevention of influenza [6,7]. Influenza vaccination of healthy working age adults can reduce the rates of influenza-like symptoms, lost workdays and physician visits [3–9]. The cost–effectiveness and cost–benefit of influenza vaccination are well established not only among adults over 65 years of age but also among younger adults [5,9]. To reduce the transmission of the virus to the vulnerable groups of the population, long-standing recommendations have included ‘high-priority’ professional

\* Corresponding author at: Department of Virology, University of Crete School of Medicine, Voutes 71110, Heraklion, Crete, Greece. Tel.: +30 2810394631; fax: +30 2810394759.

E-mail address: [spandidos@spandidos.gr](mailto:spandidos@spandidos.gr) (D.A. Spandidos).

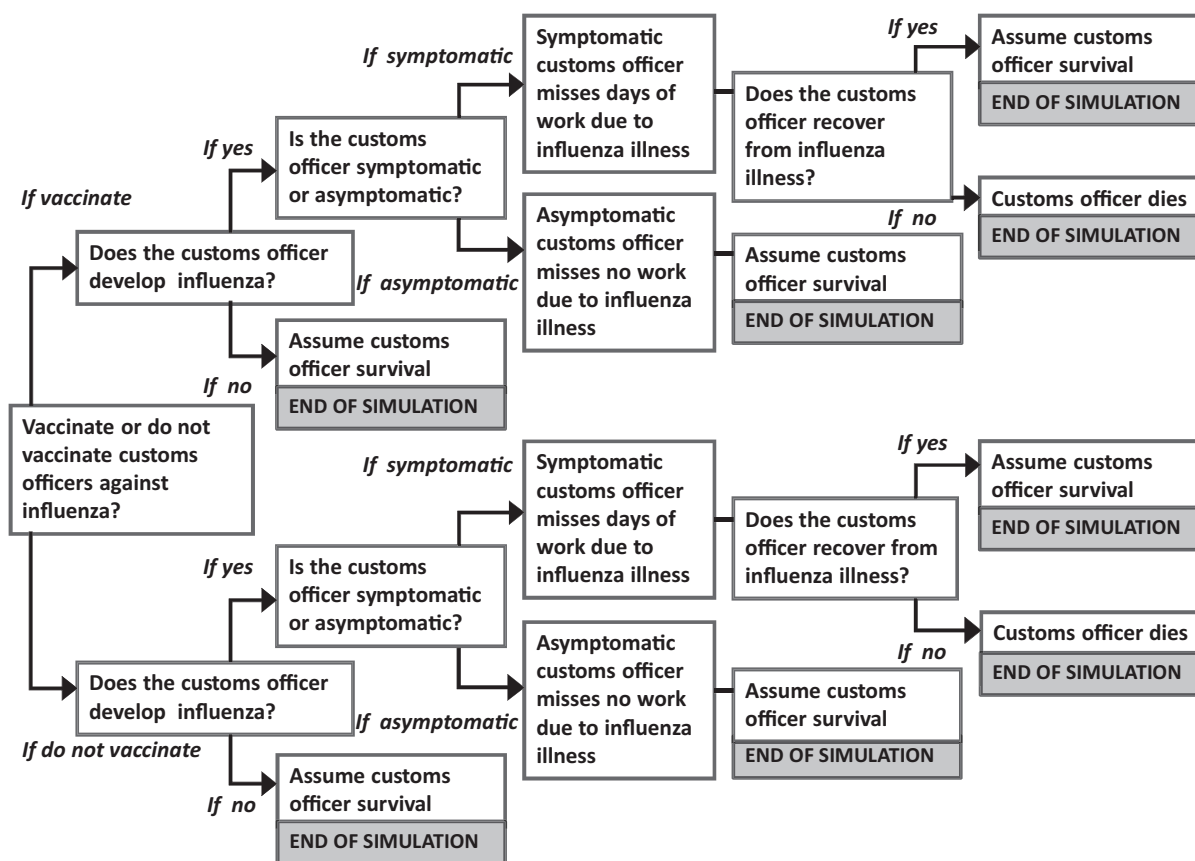


Fig. 1.

groups into the vaccination program. The vaccination of 'high-priority' target populations against influenza has been consistently recommended worldwide in order to prevent viral transmission and ensure delivery of healthcare and government services during outbreaks.

However, according to the literature, vaccination coverage among nurses and doctors remains unacceptably low [6,10,11]. A similar low acceptance for influenza vaccine has been reported among those working in care homes with nursing [12]. Little is known about the economic impact and the participation in the influenza vaccination program among other 'high-priority' professional groups. In our study, we developed and applied an economic model to assess the cost–benefit of the influenza program among customs officers in Greece. Sensitivity analyses varied key model parameters and allowed us to examine how the cost–benefit of the influenza program may vary by the probability of symptomatic influenza, the influenza attack rate and the participation rate. Using a self-administered questionnaire, we also assessed the acceptability and compliance with influenza vaccines of customs officers in Greece during the last five-year period (2006–2011) and we evaluated the effectiveness of the 2009/2010 national campaign in their participation in the vaccination program. Economic analysis was performed based on the questionnaire-assessed epidemiological characteristics during the winter 2009/2010.

## 2. Materials and methods

### 2.1. The economic model

Our analysis was based on a stochastic decision analytic computational model using TreeAge Pro 2009 (TreeAge Software, Williamstown) as previously described [13]. The model included dynamic transmission elements to simulate the decision of whether to implement an influenza vaccination program among customs officers in Greece. This model calculated the avoided costs of influenza, including lost productivity due to absenteeism and physician visits. It was assumed that all costs associated with vaccine costs and paying for the healthcare professional to administer vaccine were covered by the employer. Fig. 1 shows the decision and subsequent outcomes analysed by our decision analytic computer simulation model.

The model was applied to the 3309 customs officers of the Hellenic Authorities. Each simulation run was comprised of 1000 trials of the 3309 simulated custom officers. The model assumed that customs officers were healthy individuals aged less than 65 years. It assumed 8 h in a work-day, 5 work-days in a week, 30 min of employee time for vaccine education prior to the vaccination session and 30 min of employee time lost for waiting in the queue and vaccine administration. Each custom officer who developed influenza had a probability of developing symptomatic or asymptomatic disease. It was assumed that asymptomatic customs officers missed

**Table 1**  
Generic, influenza and vaccination parameters used in our model.

Description	Values (range)	Source
<i>Generic parameters</i>		
Number of customs officers	3309	Hellenic Ministry of Finance
Daily wage rate (Euros)	125.68 (82.2–169)	National Accounting Office of the Hellenic Ministry of Finance
Work duration per day (hours)	8	Hellenic Ministry of Finance
<i>Influenza parameters</i>		
Influenza-related absenteeism (days)	2.7 (1.5–4.9)	[14]
Percentage of illness that is symptomatic	50%, 65%, 80%	[15]
Influenza attack rate for unvaccinated employees (%)	6.6 (3.2–10.0), 20, 30	[16]
<i>Vaccination parameters</i>		
Cost of seasonal influenza vaccine (Euros)	6.62	General Committee of Trade of the Hellenic Ministry of Finance
Cost of pandemic influenza vaccine (Euros)	6.62	General Committee of Trade of the Hellenic Ministry of Finance
Cost of vaccination administration (Euros)	20.00 (20.00–50.00)	Civil Servant's Sickness Insurance Fund
Customs officer time for education (min)	30	[13]
Customs officer time per vaccination (min)	30	[13]
Efficacy of seasonal influenza vaccination (%)	80 (56–91)	[17]
Efficacy of seasonal and pandemic influenza vaccination (%)	95	Assumption

no work, while those with symptomatic influenza stayed home from work 2.7 days [14], resulting in a productivity loss. Productivity loss was calculated as the assumption of customs officer's salary in Euros through the duration of absenteeism. The mean customs officer's daily wage rate was 125.68 (82.2–169) euros according to the National Accounting Office of the Hellenic Ministry of Finance (<http://www.mof-glk.gr>). The cost of each influenza vaccine dose was 6.62 euros according to the medication price list of the General Committee of Trade of the Hellenic Ministry of Finance (<http://www.gge.gr>). The cost of vaccination administration was 20 euros according to the cost of the medical visit covered by the Civil Servant's Sickness Insurance Fund (<http://www.opad.gr>).

The model input parameters and the probability distributions, assessed according to the relevant literature sources [13–17], are presented in Table 1. Sensitivity analyses varied model parameters including the probability of symptomatic influenza, influenza attack rate and vaccine combinations (seasonal vaccine without or with pandemic vaccine). Our initial set of simulation runs for vaccination against seasonal influenza used an influenza attack rate of 6.6% based on the existing literature [16] with varying probabilities of symptomatic influenza (50%, 65% and 80%) [15]. Additional simulation runs were performed to explore pandemic scenarios with higher attack rates of 20% and 30%. Another set of scenarios explored the impact of the combination of vaccines against seasonal and pandemic influenza assuming that vaccines' effectiveness rate reaches 95% [17]. All analyses were performed for vaccination participation rates of 100%, 70% and 30%. To evaluate the economic value of the vaccination program, the following formula determined the net cost–benefit of vaccination:

$$\frac{\text{value of influenza vaccination program}}{\text{cost of influenza vaccination program}}$$

The reported negative value results represented a net cost to the employer, while all positive values indicated net cost savings to the employer.

The ratio of benefit/cost was also calculated according to the following formula:

$$\frac{\text{value of influenza vaccination program}}{\text{cost of influenza vaccination program}}$$

The reported <1 values results represented net costs to the employer, while all values >1 indicated net cost savings to the employer.

## 2.2. Vaccination program and campaign

The national program for the prevention of pandemic influenza A/H1N1 was carried out in November 2009. Customs officers were considered as a 'high-priority' target working population and were included in the first national wave of the performed vaccinations. The campaign designed by the Hellenic Centre for Disease Prevention and Control (KE.EL.P.NO.) and the Hellenic Ministry of Health and Social Solidarity (H.M.H.S.S.) included information and training materials, such as posters, hand-outs and leaflets that were mailed to all Greek customs authorities in November 2009. This material aimed to provide information on A/H1N1 influenza and the importance of influenza vaccination in the 'high-risk' as well as the general population. In addition, information about the campaign was provided in articles published in the websites of the KE.EL.P.NO. (<http://www.keel.org.gr/>) and the H.M.H.S.S. (<http://www.yyka.gov.gr/>) as well as several reports in mass media. Vaccination was voluntary and free of charge since both vaccines and medical attendance charges were covered by the employer.

## 2.3. Real time economic evaluation survey

A self-administered questionnaire was designed to evaluate (a) if customs officers had received the information material of the campaign, (b) their vaccination status during the winter seasons 2006/2007, 2007/2008, 2008/2009, 2009/2010 and 2010/2011, (c) the duration of influenza-related absenteeism during the winter season 2009/2010, (d) the number of hospitalizations given

influenza infection during the winter season 2009/2010 and (e) the presence of side-effects among vaccinated individuals. The questionnaire also included closed questions about demographics (age, gender, level of education, duration of working experience and wage rate) of our sample. A sample of 245 customs officers were randomly selected by the list of all registered customs officers of the Hellenic Authorities during the period 2007/2008. Customs officers were informed about the survey by e-mail or by post or personally and were asked to participate in the survey by completing the questionnaire. To increase participation rate and to reduce the possible bias that customs officers with a negative attitude towards vaccination feel inhibited to respond, the investigators collected the self-administered questionnaires by customs officers anonymously. Statistical analysis was performed using the SPSS computer program package (version 12.0.1 for Windows).

Economic analysis was performed retrospectively using TreeAge Pro 2009 (TreeAge Software, Williamstown) based on the questionnaire-assessed epidemiological parameter during the winter season 2009/2010. In these parameters we included the duration of absenteeism due to influenza, the percentage of hospitalizations or deaths due to influenza infection, the reported mean daily wage, the symptomatic influenza attack rate and the participation rate against seasonal and pandemic influenza during the winter season 2009/2010.

### 3. Results

#### 3.1. Economic model analysis

Table 2 shows the estimated mean net cost–benefit values (Euros) per customs officer for vaccination against seasonal influenza (A) and seasonal and pandemic influenza (B) explored using scenarios with different percentages of symptomatic illness (50%, 65%, 80%), influenza attack rates (6.6%, 20%, 30%) and participation rates (30%, 70%, 100%).

##### 3.1.1. Results for simulations with the seasonal influenza vaccine

When the participation rate was 30%, the mean net cost–benefit per customs officer ranged from –15.69 to

–15.60 euros (benefit/cost ratio < 1) in the lower symptomatic influenza rate scenarios (50%) and from 0.19 to 8.04 euros (benefit/cost ratio > 1) in the higher symptomatic influenza scenarios (80%). When participation rates were 100%, the mean net cost–benefit values ranged from –32.77 to –25.71 euros/customs officer (benefit/cost ratio < 1) in the lower symptomatic influenza rate (50%) scenarios and from 16.74 to 29.12 euros/customs officer (benefit/cost ratio > 1) in the highest symptomatic influenza rate (80%) scenarios. As the symptomatic influenza rate increased, the mean net cost–benefit values per customs officer increased across all simulations. Vaccination against seasonal influenza with a participation rate of 30% was cost-saving in all influenza scenarios with different influenza attack rates, when the symptomatic influenza rate was 80%.

##### 3.1.2. Results for simulations with the combination of seasonal and pandemic A/H1N1 influenza vaccines

When the participation rate was 30%, the mean net cost–benefit per customs officer ranged from –20.2 to –2.81 euros/customs officer (benefit/cost ratio < 1). When the participation rate increased to 70%, the program was cost-saving when the symptomatic influenza rate was 80% and the influenza attack rate was greater than 20%. When participation rates reached 100%, the mean net cost–benefit values ranged from –36.67 to –32.00 euros/customs officer (benefit/cost ratio < 1) in the lower symptomatic influenza rate (50%) scenarios. The respective ranges in the higher symptomatic influenza rate (80%) scenarios were from 0.67 to 35.42 euros/customs officer (benefit/cost ratio > 1).

#### 3.2. Real time economic analysis

Overall, self-administered questionnaires were collected from 209 customs officers, 124 (59.3%) males and 85 (40.7%) females, with a participation rate of 85.3% (209/245). Their daily wage ranged from 89 euros to 180 euros (mean daily wage 145 euros). The mean ages of the male and the female responders were 40.3 years (range 26–62 years) and 42.6 years (range 24–64 years), respectively ( $p=0.345$ , non-statistically significant). Sixty-two (29.7%) customs officers reported a working experience of more than 20 years. Thirty-five (16.7%) customs officers

**Table 2**

Mean net cost–benefit values per customs officer in Euros for vaccination against seasonal influenza (A) and seasonal and pandemic influenza (B).

	50% Symptomatic			65% Symptomatic			80% Symptomatic		
	Influenza attack rate			Influenza attack rate			Influenza attack rate		
	6.6%	20%	30%	6.6%	20%	30%	6.6%	20%	30%
<b>(A)</b>									
SIV, Participation rate 30%	–15.69	–12.84	–15.60	–10.57	–1.71	–6.98	0.19	8.04	4.80
SIV, Participation rate 70%	–24.48	–25.19	–23.06	–11.89	–2.32	5.60	–0.64	3.26	18.14
SIV, Participation rate 100%	–32.77	–27.77	–25.71	–14.74	–3.77	5.88	1.43	16.74	29.12
<b>(B)</b>									
SIV + PIV, Participation rate 30%	–20.02	–19.17	–16.68	–12.84	–8.73	–2.39	–7.69	–3.05	–2.81
SIV + PIV, Participation rate 70%	–28.55	–28.69	–24.69	–13.53	–6.18	–4.69	–0.59	1.58	20.93
SIV + PIV, Participation rate 100%	–36.67	–32.00	–33.09	–13.65	–3.99	5.67	0.67	13.70	35.42

Note: Positive values shaded in grey indicate cost savings. SIV: seasonal influenza vaccine, PIV: pandemic influenza vaccine.

**Table 3**

Mean net cost–benefit values per customs officer in Euros for vaccination against seasonal and pandemic influenza during the winter season 2009/2010.

Description	Values in Euros
<i>Cost</i>	
Mean cost per customs officer	168.1 (97.5% CI: 13.24–642.24)
<i>Benefit</i>	
Mean benefit per customs officer	160.8 (97.5% CI: 0–629.00)
<i>Net cost–benefit</i>	
Mean net cost–benefit per customs officer	–7.3 (97.5% CI: –642.24–0)

were working at the airport, 46 (22.0%) at the port, 58 (27.8%) at the office, while 70 (33.5%) reported mixed external and official duties. The proportions of customs officers vaccinated for seasonal influenza were 1.4% (3/209) in 2006/2007, 0.9% (2/209) in 2007/2008 and 1.9% (4/209) in 2008/2009. The proportion increased to 7.2% (15/209) in 2009/2010, while the respective proportion for A/H1N1 influenza was 0.9% (2/209). In 2010/2011 the respective proportion for seasonal influenza was 0.9% (2/209).

All customs offices participating in the evaluation survey indicated that they had received the provided information material about influenza and the vaccination program against influenza during the winter season 2009/2010. No vaccinated customs officer in 2009/2010 developed influenza-like symptoms. No side effects were reported among the vaccinated individuals. The symptomatic influenza rate among non-vaccinated customs officers was 25.77%. The mean duration of absenteeism due to influenza was 4.2 days (range 1–8 days) and the percentage of hospitalizations given influenza infection was 0.0%. Significantly more customs officers working at the airport or the port were vaccinated against seasonal influenza in comparison to customs officers with office duties ( $p < 0.001$ ). Other factors associated with seasonal influenza vaccination were older age ( $p = 0.036$ ), higher education ( $p = 0.102$ ) and longer working experience ( $p = 0.028$ ). Previous receipt of seasonal influenza vaccine was not associated with seasonal influenza vaccination during the winter season 2009/2010.

Results for real-time simulations based on the assessed epidemiological and economical parameters during the 2009/2010 period are presented in Table 3. The estimated mean net cost–benefit for seasonal and pandemic A/H1N1 influenza vaccine implementation in 2009/2010 was –7.37 euros/customs officer, while the estimated benefit/cost ratio was 0.957.

#### 4. Discussion

Customs officers represent a ‘high-priority’ target professional group for vaccination against influenza. They meet many people in their work and they can easily be infected but also infect others, especially at the airport or at the port. Our study suggests that implementing a vaccination program against seasonal and pandemic A/H1N1 influenza among customs officers is relatively inexpensive (<37 euros/customs officer). When the participation rate was 30%, the combination of vaccines against

seasonal and pandemic A/H1N1 influenza was not cost saving in any of the examined scenarios. When the participation rate reached 100%, the program was cost-saving even when the symptomatic rate was 65% and the influenza attack rate was 30%. Our analysis suggests that providing an influenza vaccination program can incur a substantial net benefit for customs offices, although the size of the benefit strongly depends upon the symptomatic rate of influenza as well as the participation rate of the customs officers in the applied program. Because for various reasons not all customs officers eligible for vaccination would be vaccinated, vaccination coverage of 70% or 30% was expected to be closer to our real-time evaluation. However, real-time economic analysis based on the epidemiological characteristics of our sample showed that the vaccination program in 2009/2010 was not cost-saving as long as the participation rate was unacceptably low.

Our questionnaire-based assessment provides further evidence of the acceptance by customs officers of the seasonal influenza vaccination during the 2009/2010 but not of the vaccination against the pandemic A/H1N1 influenza. In the season 2009/2010, the percentage of the customs officers reported having received the seasonal vaccine was 7.2%, while only 0.9% affirmed having received the pandemic A/H1N1 influenza vaccine. To date, several studies have reported a more restrictive attitude among the general population of different countries towards to the new pandemic A/H1N1 influenza vaccination during the 2009/2010 period [10,18–22]. Notably, Virseda et al. [10] demonstrated that the vaccination rates among 262 health-care workers from Spain in 2009 were 49.7% for the seasonal vaccine and only 16.7% for the pandemic A/H1N1 influenza vaccine. The low participation among customs officers in the vaccination program against the pandemic A/H1N1 influenza in the 2009/2010 period agrees with the relevant low rates described in the Greek general population [18] as well as in other ‘high-risk’ Greek professionals, such as nurses and doctors [19,20].

Older age and higher educational level were associated with higher participation in the vaccination program against seasonal influenza, similar to the findings by other researchers [11,18–23]. Moreover, higher vaccination uptake was also related to the nature of customs officers’ work, as perceived risk for influenza infection increased according to placement (port or airport). Interestingly, increased vaccination uptake among customs officers was not related to previous history of vaccination against seasonal influenza highlighting the possible role of the 2009/2010 campaign. However, despite the national 2009/2010 campaign, the participation of Greek customs officers in the vaccination program against seasonal and A/H1N1 influenza remained unacceptably low. This can be attributed to specific attitudinal barriers, fears and misconceptions about the pandemic A/H1N1 vaccination raised during the 2009/2010 period [10,18–20].

Our findings have to be seen in the light of specific limitations. The participation rate among customs officers was among the highest reported in the literature included other ‘high-risk populations’. Although all selected customs officers were asked to participate into the survey, it is possible that only those with certain characteristics, such as

those who have a more positive attitude towards vaccination, finally participated. To reduce the possible bias that customs officers with a negative attitude towards vaccination feel inhibited to respond, customs officers returned their questionnaires anonymously. The fact that overall rates were low supports the notion that no major selection bias was present. In our real-time analyses, the reported absenteeism by customs officers during the 2009/2010 due to influenza was significantly higher (4.2 days vs 2.7 days) compared to the respective absenteeism reported in the literature [14]. Moreover, our sensitivity analysis did not include the number of secondary infections seeded by an infective customs officer into the general susceptible host population. Indeed, there might be an additional cost–benefit related to individuals contracting influenza from the infected customs officers (e.g. family, other officers), which further highlights the crucial importance of the participation rate for the cost–effectiveness of the program against seasonal and pandemic A/H1N1 influenza.

According to the literature, there is evidence that there are ways to increase the participation of customs officers in the vaccination program against influenza by providing an on-site influenza vaccination at the workplace [13,24,25]. Several researchers have demonstrated that vaccine compliance is larger at companies with workplace vaccination program providing easier accessibility to vaccination [24]. Workplace influenza vaccination has proven to be cost-beneficial to both employers and employees by minimizing absenteeism resulting from influenza [13,25]. In the recent economic analysis by Lee et al. [13], implementing the workplace vaccination program was relatively inexpensive and cost-saving across diverse occupational groups in all examined seasonal influenza scenarios. Factors significantly associated with increased vaccination at the workplace are older age, female gender, previous company vaccination rate, higher education and increased awareness of the vaccination benefits [24,25].

However, although many worksites offer influenza vaccination at the workplace, vaccination rates against seasonal influenza among employees remain low [24]. This can be enhanced by specific targeted worksite policies supportive of influenza vaccination and putting continued efforts to expand them into practice [26]. Vaccine uptake is higher in workplaces with a targeted policy recommending vaccination of staff [9,11]. Recently, Nowalk et al. [24] demonstrated that vaccination rates in the workplace can be further improved by offering both a choice of intranasal and injectable influenza vaccines to eligible employees and by providing an incentive for being vaccinated by increasing awareness of the vaccine clinic. Due to their intervention, the overall vaccination rate in the studied 12,222 US employees increased from 39% in 2007–2008 to 46% in 2008–2009. Similar results were found by Lin et al. [25], who studied 2389 US employees aged 18–49 years, who received intranasal or injectable vaccination against influenza. New, more effective, strategies through targeted interventions should be explored to build safety perception towards influenza vaccines, encourage first time influenza vaccination and enhance vaccination rates among high-priority target populations. Important issues to be addressed include improving vaccine delivery to

current and expanded target groups, ensuring timely availability of adequate vaccine supply.

### Conflict of interest statement

The authors MM, DAS declared no conflicts of interest.

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