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Economics of Employer-Sponsored Workplace Vaccination to Prevent Pandemic and Seasonal Influenza

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Abstract

Employers may be loath to fund vaccination programs without understanding the economic consequences. We developed a decision analytic computational simulation model including dynamic transmission elements that determined the cost-benefit of employer-sponsored workplace vaccination from the employer's perspective. Implementing such programs was relatively inexpensive (<$35/vaccinated employee) and, in many cases, cost saving across diverse occupational groups in all seasonal influenza scenarios. Such programs were cost-saving for a 20% serologic attack rate pandemic scenario (−$15 to −$995) per vaccinated employee) and a 30% serologic attack rate pandemic scenario (range −$39 to −$1,494 per vaccinated employee) across all age and major occupational groups.

Keywords

Influenza; Workplace; Vaccination

Introduction

In 2009 an estimated 60% of U.S. adults over the age of 18 were employed, with approximately 16% remaining in the workforce beyond their 65th year of life.[1] Consequently, working adults comprise a large population segment which can be affected by influenza.[2] Employees spend a substantial amount of time at their place of work—on average 38.9 hours per week—with 26.5% of the workforce exceeding 40 hours per week.[3] Studies have documented contact patterns at workplace conducive to influenza's spread.[4-6] Vaccinating employees against seasonal and, in years such as 2009, pandemic

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influenza can help employers prevent influenza-induced absenteeism that leads to lost workplace productivity.[7-8]

Recognizing the central role businesses and employers play in protecting the health and safety of their employees, the Centers for Disease Control and Prevention (CDC) and the Occupational Safety and Health Administration (OSHA) have produced materials intended to guide employers in their planning and preparedness for seasonal and pandemic influenza. The guidance is intended to help employers take actions to decrease influenza spread, maintain business continuity, and secure critical infrastructure.[9-10] OSHA recommends that employers prioritize vaccination—an engineering work practice control—because it is a long-term and effective intervention that reduces reliance on employee behavioral changes such as hand hygiene and respiratory etiquette.[9] The CDC also recommends that employers: encourage employees to seek vaccination against both seasonal and pandemic influenza, offer influenza vaccination opportunities at their worksite or consider allowing employees time off from work to seek vaccination, and negotiate with insurers for coverage of influenza vaccination.[10] In February of 2010 the Advisory Committee for Immunization Practices (ACIP) released the provisional recommendation that all people 6 months of age or older receive annual influenza vaccination, unless contraindicated.[11-12]

Despite the potential benefits of vaccination, self-reports as part of the National Health Interview Survey suggest that vaccine coverage among healthy adults 18 to 49 years is only approximately 20%.[13] Offering vaccination in the workplace could increase coverage by making vaccination more convenient and reducing or eliminating the associated cost may further improve influenza vaccine uptake. Studies have shown that individuals who received influenza vaccine at work cited convenience as an important factor in the decision to be vaccinated.[14-16] Following physicians' offices, workplaces are the most common location to receive an influenza vaccination, with one-third of 18-49 year old vaccine recipients and one-fifth of 50-64 year old vaccine recipients receiving the vaccine at work.[17] The addition of workplace education programs can provide information and allay employees' concerns about influenza vaccination.

Workplace vaccination programs can be costly, requiring health worker time and diverting employees' time from work; individual employers may be loath to provide such a service without understanding its economic potential benefits. Although studies have demonstrated the cost-effectiveness of vaccinating healthy adults, few have looked specifically at employer-sponsored vaccination programs—along with associated administration and education costs—and how their economic value may vary by type of workplace.[18-21] Bridges et al and Nichol et al concluded that vaccination of working adults is cost-effective when the vaccine is well-matched to the predominant circulating strain of influenza, but may not provide an economic benefit in all years.[20-21]

Several cost-effectiveness analyses have assumed the societal and third party payor perspectives, but these approaches may not yield results directly relevant to employers who are more concerned about how such interventions will affect the budgets of their specific organizations or companies.[19,22-24] A few studies have looked at specific vaccination programs at particular work sites (including chemical plants in Brazil and Malaysia, a bank in Columbia, and textile plants in North Carolina), but the value of such interventions may vary depending on an employer's industry and firm size.[18,25-27]

We developed a computational simulation model to estimate the economic value of employer-sponsored workplace influenza vaccination across each of the top 22 major occupational groups in the United States, as defined by the Bureau of Labor Statistics. Sensitivity analyses varied key model parameters and allowed us to delineate how the cost-benefit of such strategies may vary by occupational group, effective or net reproductive number (R) of influenza (the average number of secondary cases generated per primary case during the infectious period[28-29]), vaccine cost, vaccine type [live attenuated influenza vaccine (LAIV) versus trivalent inactivated vaccine (TIV)], incentive to individual employees for vaccination, influenza scenario (pandemic vs. seasonal) and age-stratified risk of influenza. The results of our model, particularly those from the sensitivity analyses, may help guide individual employers in their decision making.

Materials and methods

Model Structure

Using TreeAge Pro 2009 (TreeAge Software, Williamstown, MA), we constructed a stochastic decision analytic computational model that included dynamic transmission elements to simulate the decision of whether to implement a workplace-based influenza vaccination program from the employer's perspective. This model accounted for the costs of workplace-based vaccination, including lost productivity from employees' participation in the vaccination queue, and productivity losses from influenza-induced absenteeism. It was assumed that the employer bore all costs associated with vaccine education and administration, including paying for a healthcare professional to administer vaccine, vaccine costs, and an educational initiative that would divert time from work productivity. Previously developed materials, including videos, online content and printable handouts freely available from the U.S. Department of Health and Human Services flu.gov website and the U.S. Centers for Disease Control and Prevention Seasonal Influenza website were the materials selected for the employee educational intervention in this analysis.[12,30]

Figure 1 is a graphic representation of the decision and subsequent outcomes analyzedby our cost-benefit economic model. The grey box to the left represents the decision (whether or not employees should be vaccinated against influenza in the workplace) and the subsequent boxes represent possible outcomes; the probability of each event and its attendant costs are drawn from a set of model input parameters and probability distributions, as defined in Table 1. Each new case generated via workplace contact cycles into the model and progresses through until a terminus is reached. An employee's risk of contracting influenza depended on whether he or she received an influenza vaccine and the efficacy of that vaccine. Baseline analyses focused on the impact on the vaccine recipient and did not consider indirect protection conferred to non-vaccinated employees. Additional scenarios incorporated transmission into the model whereby an infected individual generated a number of additional cases at work, based on the value of R input into the model.

Each employee who developed influenza had a probability of developing symptomatic or asymptomatic disease. It was assumed that asymptomatic individuals (whether infectious or not) missed no work, while those with true symptomatic influenza or influenza-like-illness (ILI) stayed home from work (the duration of this absenteeism determined by a probability draw from a uniform distribution ranging from 1.5 to 4.9 days), resulting in a productivity loss to the employer equivalent to that employee's salary through the duration of absenteeism. Our model did not differentiate between ILI and true influenza disease for symptomatic individuals, as this distinction cannot truly be made without clinical laboratory testing. The percent of individuals with influenza disease who are symptomatic has been reported to range widely, from 40%-50% for 2009 H1N1 and 67-86% for seasonal influenza.[31-34] For the purpose of these analyses, the cost of interim replacement labor was not considered.

A small percentage of employees did not survive influenza (the baseline scenario usedthe seasonal influenza case fatality rate for healthy median working-age adults) and accrued a productivity loss equivalent to the median tenure of employment, defined as the point at which half of all workers had more tenure and half had less tenure at the same firm.[35] The model assumed that employees were otherwise healthy individuals.

For each simulation run, the following formula determined the incremental cost-benefit of vaccination:

$$\text{Cost}_{\text{Workplace Influenza Vaccination}} - \text{Cost}_{\text{No Workplace Influenza Vaccination.}} \quad (1)$$

Data Inputs

Table 1 lists various probability and cost data inputs for our model and the corresponding data sources used. All probability variables drew from beta distributions; all other variables drew from gamma distributions, except for the duration of absenteeism which drew from a uniform distribution ranging from 1.5 to 4.9 days, based on data from a literature review on influenza and work absenteeism.[2] All costs were converted into 2009 U.S. dollars using a 3% discount rate. Our model assumed 8 hours in a workday, 5 workdays in a week, 30 minutes of employee time for vaccine education prior to the vaccination session, 30 minutes of employee time lost for wait in the queue and vaccine administration, and 5 minutes of nurse time for brief questions and administration per employee receiving an influenza vaccination.[19]

Sensitivity Analyses

Sensitivity analyses systematically varied key model variables including the probability of symptomatic influenza or influenza-like-illness (50% to 80%), the duration of absenteeism (1.5 to 4.9 days), vaccine cost (TIV: $11.63 [95% CI: $8.12-$15.14] and LAIV: $19.70 per dose, respectively), and influenza risk or serologic attack rate among employees (3.2% to 30%).[9] Varying the last parameter simulated pandemic influenza scenarios. Additional scenarios examined trivalent inactivated (TIV) versus live attenuated influenza vaccine (LAIV) use.

The base case scenario (where R=0) only focused on vaccine benefits for the individual and did not account for secondary cases that an infected employee might generate in the workplace during the infectious period. Another set of scenarios accounted for potential transmission of influenza in the workplace by varying the R of influenza from 1.2 to 1.6. Finally, a set of scenarios examined the cost-benefit of offering each employee a financial incentive to get vaccinated. For each simulation run, probabilistic sensitivity analyses evaluated the effects of simultaneously varying all input parameters over the ranges listed in Table 1.

Occupational Groups

Every workplace consists of a mixture of individuals serving various roles. To help employers understand how their specific mixture of employees may affect the economic impact of vaccination, sensitivity analyses explored the economic effects of vaccinating individuals from each of the top 22 major occupational groups in the United States as defined by the Bureau of Labor Statistics and listed in Table 2.[36]

Results

Each simulation run was comprised of 1,000 trials of 1,000 simulated employees, resulting in 1,000,000 hypothetical vaccination decisions. From here on, all reported positive dollar value results represent a net cost to the employer while all negative dollar values indicate net cost savings to the employer.

Our initial set of seasonal influenza simulation runs used a seasonal influenza attack rate stratified by age (6.6% ± 1.7% for employees age 18-64 and 9.0% ± 2.4% for employees over the age of 65) and only considered the effects of vaccination on the vaccine recipient and not on other unvaccinated employees (R=0). Additional scenarios explored the impact of varying R (R=0, 1.2 and 1.6), vaccine type (TIV or LAIV) and the percentage of influenza cases that were symptomatic (50%, 65%, and 80%). Results for all 22 major occupational groups and the median wage American worker (denoted "all occupations"), presented as median incremental cost (US$) per employee vaccinated are presented in Table 3 (TIV) and Table 4 (LAIV). In Table 3 the range of values in each cell reflects the range of 3 median costs—for adults aged 18-49, 50-64, and over 65—in each scenario.

Trivalent Inactivated Vaccine (TIV) Scenarios

When R=0, vaccination was never cost saving. When R was held constant and the probability of symptomatic illness and subsequent productivity loss is ≤ 50%, the cost per employee vaccinated increased with increasing wage. The cost per employee vaccinated decreased with increasing wage when the percent of symptomatic illness was ≥ 65%. As R and the percentage of symptomatic illness increased, the cost per employee vaccinated decreased; employee vaccination was cost saving for the median wage American worker in all TIV and LAIV scenarios when R=1.2 or 1.6, and cost saving to near cost-neutral for occupations with lower median hourly wages. Per employee cost decreased with increasing age across all simulations, e.g. cost was lower for 65+ year old employees than for 50-64 year olds, and lower still compared to 18-49 year olds, for whom the cost per employee vaccinated was highest across all scenarios.

Live Attenuated Influenza Virus (LAIV) Scenarios

Results for simulations with LAIV are presented in Table 4. The median cost per employee is for adults ages 18-49 only, as LAIV isn't FDA licensed for use in older adults.[37] For a given R, when the probability of symptomatic illness and subsequent productivity loss is ≤ 50%, the cost per employee vaccinated increases with increasing hourly wage. The cost per employee vaccinated decreases with increasing wage when the percent of symptomatic illness is ≥ 65%.

Cost per employee vaccinated was slightly higher for LAIV scenarios than for TIV and yielded cost savings across fewer of the major occupational groups, owing to the higher cost of the LAIV vaccine.

Pandemic Influenza Scenarios

Another set of scenarios explored pandemic scenarios with higher serologic attack rates of 20% and 30% (data not shown). For pandemic scenarios with an attack rate of 20% and TIV where protection to the unvaccinated was not considered (R=0), employee vaccination generated cost savings across all age and occupational groups (median price per employee vaccinated ranging from −$598 to −$25). When R increased to 1.2 the cost savings increased (range: −$843 to −$66 per employee vaccinated), and when R=1.6, the cost savings were higher still (range: −$882 to −82). An attack rate of 30% yielded even greater cost savings per employee vaccinated: when R=0 the range was −$1,116 to −$44; a higher R of 1.2 yielded a range of −$1,200 to −$110, and R=1.6 yielded the highest cost savings of −$1,273 to −$132 per employee vaccinated

All scenarios across all occupational groups using LAIV (in the 18-49 year old age group only) yielded cost savings. When the attack rate was 20% and R=0 the savings per employee vaccinated ranged from −$615 to −$15. An R of 1.2 yielded greater cost savings with a range from −$829 to −$57 per employee, and scenarios where R=1.6 resulted in the greater savings (range: −$995 to $68 per employee vaccinated). Use of LAIV during a pandemic with an attack rate of 30% offered increased cost savings compared to scenarios with lower attack rates; when R=0 the range across occupational groups was −$1,095 to −$39 per vaccinated employee. Increasing R to 1.2 resulted in higher cost savings (range: −$1,354 to −$103 per vaccinee), and an R of 1.6 yielded even greater cost savings of −$1,494 to −$117 per employee vaccinated.

During a pandemic scenario with an elevated influenza attack rate both TIV and LAIV yielded cost savings for employees in all 22 major occupational groups, regardless of whether transmission in the workplace is accounted for. These savings were slightly less for LAIV than TIV scenarios because of the higher cost of the LAIV vaccine.

Employee Incentive

Although not conducted as an explicit analysis, the added cost of employee incentives for vaccination can be estimated by adding the cost of the incentive (per employee) to the relevant median incremental cost in Table 3 or 4. This approach allows flexibility in the interpretation and application of our results, without the limitation of a fixed incentive cost. For example, if an employer was interested in the offering an incentive (such as a $10 gift card) to employees who accept vaccination $10 should be added to the medianincremental cost of vaccination per employee.

Discussion

Our study suggests that employer-supported workplace-based influenza vaccination can be relatively inexpensive (<$35 per vaccinated employee) or cost saving for employers, even when ignoring the benefits of vaccination to unvaccinated employees. These findings hold across a wide variety of occupational groups. For many occupational groups, vaccination may even be cost saving; employers could gain money by implementing such programs. Factoring in the potential benefits of vaccination for the unvaccinated only improves the cost savings of vaccination programs. Certain employers will realize a greater return on influenza vaccination, especially those investing heavily in the productivity of their employees.

Improving access, by means of an employer sponsored in-house program or paid time to seek vaccination, may also serve as an incentive to increase vaccine uptake; employees may be reluctant to pay out-of-pocket for the influenza vaccine or take time off from work for immunization if it will affect their pay or accrued personal time. Future studies are needed to further delineate the impact of incentives on vaccine uptake among the general non-healthcare working population.

Because adults spend a large amount of time at their place of work, an employer's decision to implement a workplace-based influenza vaccination program can have broad impact on the health of individuals, a workplace and the total population. The health of employees is central to workplace productivity, and subsequently, local, national and global economies and infrastructure. The CDC and OSHA have recommended that businesses and employers develop preparedness plans for seasonal and pandemic influenza that prioritize employee vaccination.[9-10] Employee vaccination programs are an example of engineering work practice controls — enduring and effective interventions that do not rely on individual behavior change. Employers who subsidize workplace vaccination programs stand to see significant a significant return on their investment, particularly during a severe influenza season or pandemic when employee productivity may be interrupted by influenza-related absenteeism.

Employers collectively bearing the costs of influenza immunization could alleviate some of the burden on the already strained public health and medical systems. Studies have implied that many businesses are not currently implementing influenza vaccination programs, even though recent concerns of a pandemic have motivated some businesses to develop pandemic influenza preparedness plans.[14,17,38-39] One potential problem is that existing studies have been from specific workplaces at specific locations. For example, a study of a Malaysian petrochemical plant demonstrated that workplace vaccination clearly decreased influenza-like illness rates and absenteeism.[26] A cost-benefit analysis of a workplace vaccination program at a Brazilian pharma-chemical company yielded a net benefit of $121,441 or $35.45 per vaccinated employee in 1997 U.S. dollars.[25] A clinical trial at six North Carolina textile plants showed that a vaccination program saved $22.36 per lost workday and $2.58 per dollar invested.[18] A prospective observational study at a Columbian bank estimated an employer savings of $6.40 to $25.80 US per vaccinated employee. A vaccine campaign at First Data Resources Limited in Basildon, Essex UK, resulted in substantial decreases in influenza-like illness.[40] It is not clear, however, if employers view results from a limited number of workplaces as being applicable to their unique setting.

Constructing economic models from the employer's perspective can help employers understand the value of vaccination. Many existing economic models that take the perspective of society and third party payors may be helpful in making policy and insurance coverage and reimbursement decisions but may not motivate individual employers. Although cost-effectiveness models can provide important information to policy-makers, employers may not be interested in translating these to their individual situations. The focus of most individual employers is to maintain the profitability of their businesses, especially in difficult economic climates. While demonstrating the worth of a public health or medical intervention to society may appeal to the altruism of some employers, demonstrating the potential positive impact of an intervention on a business's profit and loss statements may be an easier argument to make.

Rather than make decisions, computational models provide information to help employers make decisions with respect to their own set of unique circumstances. In the end, people—not computational models—make decisions, but models can help elucidate relationships, factors, and effects that are not readily apparent and provide rough benchmarks. Employers can then adapt model findings accordingly and implement appropriately tailored solutions.

Limitations

All computational simulation models simplify real life situations and cannot completely represent every possible event and outcome that may result from vaccination or influenza. Data inputs for our model came from different studies with varying sample sizes and quality of design. Our model used distributions of parameters and may not fully reflect the socio-demographic, operational, and financial heterogeneity of an individual workplace.

By design, our model remained conservative about the benefits of employer-sponsored vaccination. It did not include a number of additional costs that could arise from influenza infection. First, we assumed employees to be otherwise healthy individuals who did not suffer extended work absences (more than one work week) or substantial absenteeism due to hospitalization for influenza; additionally, the productivity loss attributable to presenteeism (in the case of an ill employee who continues to work), including any time lost for an outpatient medical visit, was not accounted for. Second, our model did not address how the appearance of influenza, especially pandemic influenza, in a workplace may affect the productivity or attendance of healthy individuals and fears of infection may keep employees from showing up to work or impact productivity.[41-42] Third, the model assumed that employers would not bear any costs of treating influenza and its symptoms (e.g., over-the-counter medications, tissues, and insurance premiums) when employers may bear these costs. This is especially true of employers who contract with occupational physicians or maintain workplace health clinics.[43] To remain conservative about the benefits of vaccination, we only accounted for cases that could be generated directly by an employee becoming infected. In actuality, an infected employee could generate a cascade of cases (i.e., the employees whom he or she infected could in turn infect others). However, the number of resulting cases could vary substantially by different mixing patterns and vaccination coverage (employees could have been vaccinated outside the workplace). Preventing this cascade of cases would only add to the value of employee vaccination.

Not all workplaces will have the resources (e.g. computer equipment, meeting space, language translation services and funding) to implement more complex education programs utilizing computer- or internet-based content. Therefore, we chose freely available (on-line) content for our educational materials. However, individual employers may elect to incorporate different, more expensive educational programs, including print materials or sessions with health educators. When deciding whether to sponsor a workplace vaccination campaign, employers should review their individual company's financial circumstances, and how the amount of funding available compares to the cost of implementing a workplace vaccination program. The cost of vaccine and administration/disposal supplies, and healthcare worker wages may vary depending on the vaccine presentation (e.g., TIV and/or LAIV) offered and affect the overall cost of a program.

Salaries are an imperfect proxy for employee productivity; pay is not necessarily commensurate with an employee's worth to a firm and may underestimate the full value of an employee's time to the employer. Certain key personnel, especially those with supervisory roles or pivotal technical skills, may influence the productivity of many other employees. Employees that interface regularly with clients or other outside individuals (e.g., teachers with students, health care workers with patients, salespeople with customers, and restaurant personnel with diners) may have a great impact on the firm's return business and revenues. Model input parameters, such as attack rate and R, are not available for all 22 of the major occupational groups included in our analyses, which may limit our ability to fully capture workplace dynamics. The results of sensitivity analyses, including those for attack rate and R across a range of occupational groups, may be referenced as benchmarks for settings in which these parameters are known.

Conclusions

Implementing workplace seasonal or pandemic influenza vaccination appears to be relatively inexpensive and potentially cost-saving for a wide variety of employers in diverse industries. Because employees comprise a large proportion of the overall population and spend a substantial amount of time at work, employer decisions may be important for overall influenza control. While demonstrating the worth of an influenza vaccination to society may appeal to the altruism of some employers, demonstrating the potential positive impact of vaccination on a business's profit and loss statements provides relevance to individual employers who seek to maintain their firm's profitability throughout the influenza season. Individual employers could compare their prevailing conditions with the benchmarks in our model to help determine their optimal local vaccination strategies.

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Figure 1.
Schematic of the decision (whether to implement a workplace-based influenza vaccination program from the employer's perspective) and subsequent outcomes analyzed by our stochastic decision analytic computational model

TABLE 1

Model Inputs

Description (Units)	Mean	95% Range Lower Limit	95% Range Upper Limit	Source
COSTS (US$)				
Nurse Hourly Salary	27.20	13.85	56.57	[36]
Inactivated Influenza Vaccine (TIV)	11.63	8.12	15.14	[44]
Live Attenuated Influenza Vaccine (LAIV)	19.70	---	---	[44]
DURATIONS				
Nurse Time Per Vaccination (minutes)	5	---	---	[19]
Employee Time for Education (minutes)	30	---	---	Assumption
Employee Time Per Vaccination (minutes)	30	---	---	[19]
Vaccine Side Effects (days)	0.75	0.5	1	[45]
Influenza-related absenteeism (days)	2.7	1.5	4.9	[2]
Work Hours per Day	8	---	---	Assumption
PROBABILITIES (%)				
Influenza for Unvaccinated Employee (18-49 yrs)	6.6	3.2	10.0	[46]
Influenza for Unvaccinated Employee (50-64 yrs)	6.6	3.2	10.0	[46]
Influenza for Unvaccinated Employee (65+ yrs)	9.0	4.2	13.8	[46]
Death given Influenza Infection (18-49 yrs)	0.009	0.003	0.015	[46]
Death given Influenza Infection (50-64 yrs)	0.134	0.044	0.224	[46]
Death given Influenza Infection (65+ yrs)	1.17	0.390	1.95	[46]
Vaccine Efficacy	80	56	91	[47]

SENSITIVITY ANALYSES	Values	Source
Effective Reproductive Number (R)	0.0, 1.2, 1.6	Assumption
Employee Age (years)	18-49, 50-64, 65+	Assumption
Probability of Influenza (pandemic setting)	Baseline (as above), 20%, 30%	Assumption
Percentage of Illness that is Symptomatic	50%, 65%, 80%	[19,31-34, 48-49]

Table 2

Characteristics of the 22 Major Occupational Groups in the United States—May 2008[24]

Occupational Group ***Ranked By Median Hourly Wage (Low to High)***	**Number Employed**	**Median Wage (80% Range) in US$**	**Median Length of Tenure in Years**
All Occupations *(Based on the median wage & tenure of working adults)*	***135,185,230***	***15.57 (8.02, 37.99)***	***4.1***
Food Preparation and Serving Related	11,438,550	8.59 (6.89, 14.41)	2
Farming, Fishing, and Forestry	438,490	9.34 (7.71, 18.27)	3.1
Personal Care and Service	3,437,520	9.82 (7.19, 18.64)	2.6
Building and Grounds Cleaning and Maintenance	4,429,870	10.52 (7.48, 18.07)	3.6
Sales and Related	14,336,430	11.69 (7.43, 34.23)	2.9
Healthcare Support	3,779,280	11.80 (8.25, 18.48)	3.1
Transportation and Material Moving	9,508,750	13.14 (7.89, 24.63)	3.8
Production	9,919,120	13.99 (8.53, 25.11)	5
Office and Administrative Support	23,231,750	14.32 (8.63, 24.30)	4.2
Protective Service	3,128,960	16.65 (8.73, 34.05)	5.9
Construction and Extraction	6,548,760	18.24 (10.69, 33.81)	3.5
Community and Social Services	1,861,750	18.38 (10.62, 32.03)	4.8
Installation, Maintenance, and Repair	5,374,850	18.60 (10.46, 30.99)	5
Arts, Design, Entertainment, Sports, and Media	1,804,940	19.99 (9.33, 43.18)	3.4
Education, Training, and Library	8,451,250	21.26 (9.58, 38.84)	5.4
Healthcare Practitioner and Technical	7,076,800	27.20 (13.85, 56.57)	4.9
Life, Physical, and Social Science	1,296,840	27.51 (14.56, 52.07)	4
Business and Financial Operations	6,135,520	27.89 (15.88, 49.59)	4.6
Architecture and Engineering	2,521,630	32.09 (17.31, 54.65)	6.4
Computer and Mathematical Science	3,308,260	34.26 (18.04, 56.69)	4.5
Legal	1,003,270	34.49 (16.04, [**])	4.3
Management	6,152,650	42.15 (20.40, [**])	6

NOTE:

[**] This wage is equal to or greater than $80.00 per hour and not reported by the U.S. Bureau of Labor Statistics.

Table 3

Median Incremental Cost per Employee (US$) for Employer-Sponsored Seasonal Influenza Vaccination—TIV

Occupational Group *Ranked By Median Hourly Wage (Low to High)*	50% Symptomatic			65% Symptomatic			80% Symptomatic		
	Workplace R[a]			Workplace R[a]			Workplace R[a]		
	0	**1.2**	**1.6**	**0**	**1.2**	**1.6**	**0**	**1.2**	**1.6**
All Occupations *(based on median wage & tenure)*	*18 to 20*	*−17 to −9*	*−28 to −10*	*14 to 15*	*−21 to −20*	*−31 to −27*	*8 to 9*	*−28 to −26*	*−38 to −36*
Food Preparation & Serving Related	16 to 17	−2 to 2	−8 to 5	14 to 15	−4 to −2	−10 to −9	12 to 12	−6 to −6	−13 to −11
Farming, Fishing, & Forestry	17 to 17	−4 to 1	−11 to 3	14 to 14	−7 to −4	−13 to −12	10 to 11	−10 to −7	−18 to −14
Personal Care & Service	17 to 17	−4 to −2	−3 to 0	14 to 14	−8 to −5	−14 to −9	11 to 12	−11 to −11	−19 to −16
Building and Grounds Cleaning & Maintenance	17 to 18	−4 to 0	−12 to 2	14 to 14	−8 to −4	−14 to −12	11 to 12	−10 to −7	−18 to −16
Sales & Related	18 to 19	−12 to −7	−16 to −6	14 to 14	−19 to −12	−28 to −25	9 to 10	−20 to −19	−32 to −30
Healthcare Support	17 to 18	−7 to 0	−14 to 1	14 to 15	−9 to −4	−17 to −14	11 to 11	−12 to −12	−20 to −17
Transportation & Material Moving	17 to 19	−9 to −2	−9 to −5	14 to 14	−12 to −10	−22 to −18	10 to 10	−18 to −14	−27 to −26
Production	18 to 19	−10 to −5	−12 to −3	14 to 15	−16 to −11	−24 to −18	10 to 10	−19 to −18	−29 to −25
Office and Administrative Support	18 to 19	−10 to −4	−19 to −4	14 to 14	−15 to −13	−22 to −20	9 to 10	−19 to −18	−28 to −27
Protective Service	18 to 20	−16 to −8	−20 to −10	14 to 15	−20 to −19	−32 to −30	9 to 10	−28 to −27	−40 to −36
Construction & Extraction	19 to 21	−19 to −8	−31 to −12	14 to 14	−24 to −19	−35 to −33	8 to 9	−28 to −28	−42 to −38
Community & Social Services	19 to 20	−18 to −11	−29 to −13	14 to 14	−22 to −14	−37 to −30	9 to 10	−28 to −28	−40 to −37
Installation, Maintenance, & Repair	19 to 21	−15 to −10	−29 to −11	14 to 16	−23 to −21	−34 to −30	7 to 9	−28 to −27	−41 to −40
Arts, Design, Entertainment, Sports, & Media	19 to 22	−22 to −14	−34 to −20	14 to 14	−27 to −22	−44 to −36	9 to 9	−36 to −36	−55 to −49
Education, Training, & Library	20 to 22	−21 to −13	−34 to −18	14 to 15	−27 to −22	−41 to −35	6 to 10	−34 to −32	−51 to −47
Healthcare Practitioner & Technical	21 to 24	−36 to −23	−54 to −35	14 to 15	−42 to −36	−59 to −55	5 to 6	−58 to −51	−73 to −69
Life, Physical, & Social Science	21 to 23	−36 to −28	−52 to −26	14 to 17	−44 to −30	−61 to −56	4 to 6	−51 to −44	−70 to −63
Business & Financial Operations	22 to 24	−35 to −26	−52 to −33	13 to 14	−40 to −38	−59 to −57	5 to 6	−51 to −48	−67 to −62
Architecture & Engineering	23 to 26	−40 to −26	−60 to −36	13 to 17	−48 to −39	−66 to −50	4 to 5	−58 to −57	−74 to −73
Computer & Mathematical Science	19 to 25	−39 to −29	−64 to −38	14 to 16	−50 to −45	−75 to −70	3 to 5	−60 to −59	−86 to −84
Legal	24 to 28	−50 to −38	−74 to −53	12 to 15	−61 to −51	−86 to −75	2 to 4	−72 to −69	−98 to −93
Management	25 to 30	−62 to −41	−89 to −58	12 to 14	−68 to −66	−95 to −91	1 to 2	−83 to −75	−115 to −103

NOTE: Negative values (shaded in grey) indicate cost savings.

[a] R represents the effective reproductive number (R) of influenza within a workplace. This is the average number of secondary cases generated per primary case during the infectious period. The age-stratified serologically confirmed influenza attack rates assumed for the above scenarios are: 6.6% (95% CI: 3.2%-10.0%) for employees age 18-64 and 9.0% (95% CI: 4.2%-13.8%) for employees over the age of 65.

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Table 4

Median Incremental Cost per Employee (US$) for Employer-Sponsored Seasonal Influenza Vaccination—LAIV

Occupational Group *Ranked By Median Hourly Wage (Low to High)*	50% Symptomatic			65% Symptomatic			80% Symptomatic		
	Workplace R[a]			Workplace R[a]			Workplace R[a]		
	0	**1.2**	**1.6**	**0**	**1.2**	**1.6**	**0**	**1.2**	**1.6**
All Occupations *(based on median wage & tenure)*	*29*	*1*	*−8*	*23*	*−10*	*−21*	*17*	*−16*	*−29*
Food Preparation & Serving Related	25	9	6	23	6	1	20	2	−4
Farming, Fishing, & Forestry	26	8	2	22	3	−5	19	−2	−9
Personal Care & Service	26	8	2	22	2	−2	20	−3	−9
Building and Grounds Cleaning & Maintenance	27	8	3	23	5	−4	19	−2	−9
Sales & Related	28	0	−10	22	−7	−13	19	−9	−21
Healthcare Support	26	7	1	22	4	−6	19	−1	−12
Transportation & Material Moving	26	5	−6	23	−3	−11	18	−8	−16
Production	27	3	−5	23	0	−9	19	−9	−15
Office and Administrative Support	27	3	−3	23	−1	−12	18	−9	−18
Protective Service	28	−1	−11	23	−11	−21	18	−17	−28
Construction & Extraction	28	−1	−12	22	−9	−24	17	−18	−28
Community & Social Services	28	−1	−11	23	−6	−19	17	−19	−32
Installation, Maintenance, & Repair	29	−1	−14	23	−9	−21	17	−19	−32
Arts, Design, Entertainment, Sports, & Media	30	−6	−18	22	−16	−21	17	−25	−41
Education, Training, & Library	29	−2	−19	23	−14	−25	17	−24	−34
Healthcare Practitioner & Technical	32	−16	−26	22	−32	−48	15	−42	−63
Life, Physical, & Social Science	32	−14	−30	23	−23	−42	14	−37	−62
Business & Financial Operations	32	−11	−28	22	−25	−43	17	−36	−60
Architecture & Engineering	33	−13	−39	25	−27	−52	13	−46	−70
Computer & Mathematical Science	34	−20	−38	24	−27	−57	15	−51	−68
Legal	36	−23	−54	24	−38	−68	10	−62	−90
Management	35	−32	−54	23	−54	−78	10	−75	−101

NOTE: Negative values (shaded in grey) indicate cost savings.

[a] R represents the effective reproductive number (R) of influenza within a workplace. This is the average number of secondary cases generated per primary case during the infectious period. The serologically confirmed influenza attack rate assumed for adults 18-49 in the above scenarios was 6.6% (95% CI: 3.2%-10.0%).