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Workplace Vaccination against Influenza in Malaysia: Does the Employer Benefit?

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Abstract: Workplace Vaccination against Influenza in Malaysia: Does the Employer Benefit?: Anne TASSET-TISSEAU *et al.* Sanofi Pasteur, France—This study was designed to evaluate the health and economic benefits of a workplace vaccination programme against influenza funded by the employer. Employees of a Malaysian petrochemical plant volunteered to take part in this prospective, non-randomised, non-placebo-controlled study. Demographic and health information, including influenza-like symptoms, sick leave and post-vaccination adverse events were collected via questionnaires. Cost-benefit analyses were performed from the employer's perspective. Results: A total of 1,022 employees took part in the study, with 504 choosing to be vaccinated against influenza, and 518 remaining unvaccinated. The rate of influenza-like illness (ILI) was lower among vaccinated (8.13%) than non-vaccinated subjects (30.31%). Fever and respiratory symptoms were associated with all ILI cases. ILI-related sick leave was taken by 58.54% of vaccinated employees with ILI and 71.34% of non-vaccinated employees with ILI. Vaccination was financially beneficial, with the employer saving up to US$ 53.00 per vaccinated employee when labour costs only were considered. Savings rose to up to US$ 899.70 when the operating income of each employee was also considered. Workplace vaccination of healthy adults against influenza had a clear impact on ILI rates, absenteeism and reduced productivity in this Malaysian company. The health benefits translated into financial benefits for the employer, with cost savings significantly outweighing the costs of the vaccination programme.
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Influenza is a highly infectious, acute, febrile illness primarily affecting the respiratory tract and is characterised by symptoms including fever (38–40°C), headaches, myalgia, sore throat and inflammation of the respiratory tract[1]. Infection follows a seasonal pattern, affecting northern, temperate zones during winter and the tropics during the rainy season[1]. In Malaysia influenza occurs throughout the year. Based on the surveillance that has been conducted since 1997 there are two peaks: the major peak is observed from the months of April to August and a minor peak occurs in the months of October to January[2].

While influenza is commonly misconceived as an inconvenient infection, the elderly and patients with underlying chronic medical conditions (e.g. chronic pulmonary or cardiovascular disorders, metabolic disorders, haemoglobinopathies or immunosuppression) are at high risk of complications associated with influenza, including heart failure, pneumonia, respiratory insufficiency and, ultimately, death. The US Department of Health Centers for Disease Control and Prevention identified influenza combined with pneumonia as one of the top ten causes of death, with over 60,000 deaths per year due to influenza and pneumonia in 2000 and 2001[3]. Influenza infections in the workforce are a major cause of absenteeism and disease burden[4–7]. Influenza may account for as much as 12% of sick leave time in the UK[8]. Presenteeism—being at work but unable to perform optimally—is another serious consideration for employers whose employees have influenza and influenza-like illness (ILI)[9].

The potential health and economic benefits of vaccinating the workforce against influenza have been demonstrated[8, 10, 11]; however, scepticism about the effectiveness vaccination remains[8]. Vaccination against

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influenza is currently considered to be the best method of preventing influenza[12–14]. However, uptake of workplace vaccination schemes is suboptimal[15–17].

Workplace influenza vaccination campaigns can provide health benefits and reduce the financial losses that result from influenza even when programme costs are considered[8, 18, 19], although vaccination is not recommended universally[20]. Therefore, it is necessary to consider the potential benefits of workplace vaccination against influenza, wholly or partially financed by the employer, on a company-by-company basis.

This study evaluated the health and economic impact of a workplace vaccination programme in a Malaysian petrochemical company. The objectives of this study were to determine whether vaccination against influenza decreased the rate of influenza-like illness, together with resultant absenteeism and presenteeism, as well as determining whether vaccination had economic benefits for the employer.

Methods

This prospective, non-randomised, non-placebo-controlled cost-benefit study of workplace vaccination was performed at Petronas, a Malaysian petrochemical company. Vaccinations were scheduled to take place between 15 March and 15 April, 2001. Information about ILI and episodes of fever was collected between 15 April and 12 October, 2001. The study was designed to evaluate the health benefits of vaccination as well as the financial benefits to the employer.

Volunteers from the company's employees were recruited by dissemination of information and advertising via the company's internal information services (internet, fax, notice boards and newspapers). The study aimed to recruit two cohorts, each with approximately 500 volunteers. Eligibility criteria included full-time employment, age between 18 and 64 yr, not being at high-risk of complications as a result of influenza, not diagnosed with influenza in the preceding three months nor vaccinated against influenza during the winter of 2000 (from April till October). After recruitment, workers chose whether or not to be vaccinated.

Eligible volunteers completed a questionnaire in order to provide demographic data, medical history and employment-specific data. This information included the number of people living in each household, the employee's education, level of responsibility within the workplace and any underlying chronic medical conditions considered to be risk factors for influenza. Questionnaires included two analogue scales for health status and ability to perform usual activities. Enrolled subjects self-rated their level on each scale, scored between 0 (worst possible health status/inability to perform usual activity) and 10 (normal health status for someone at the same age / ability to perform all usual activities).

The cohort of subjects choosing to be vaccinated received one dose of an inactivated, split influenza vaccine (VAXIGRIP®, Aventis Pasteur, Lyon, France). Vaccinated subjects (n=504) completed additional questionnaires describing adverse events (fever, tiredness, muscle aches, headache, allergic reaction and pain, redness, itchiness and swelling at the injection site) occurring 7 d after vaccination. Once every two months for 6 months after the vaccination period, all volunteers, both vaccinated and non-vaccinated, reported details of any episodes of ILI, defined as the occurrence of a respiratory illness of at least two days' duration having at least one systemic symptom—fever, chills, myalgia—and at least one respiratory tract symptom—rhinorrhoea, sore throat, cough, hoarseness[29].

Vaccine effectiveness was calculated in two ways:
% effectiveness in ILI rate reduction =
100 × (ILI rate in non-vaccinated cohort—ILI rate in vaccinated cohort)/ ILI rate in non-vaccinated cohort.

% effectiveness in rate of absence (ROA) =
100 × (ROA in non-vaccinated cohort—ROA in vaccinated cohort)/ ROA in non-vaccinated cohort.

Rates of ILI or absence were calculated as:
the number of periods of ILI or sick leave/number of subjects in the cohort.

Health economic analyses were performed as follows:
The cost-benefit evaluation of the vaccination programme was performed from the perspective of the employer, focusing on the direct vaccination programme costs. The costs included purchase of the vaccine, materials and vaccine administration, time away from work for the employees to be vaccinated, and adverse events affecting productivity (Table 1). The benefits of vaccination were defined as avoidance of costs associated with absenteeism because of ILI and presenteeism. Presenteeism is defined as presence at work after ILI whilst operating at reduced efficiency[21]. The calculation formulas for absenteeism and presenteesim are provided in the appendix.

The effects of presenteeism were tested using three hypothesised levels of effectiveness at work while suffering the effects of ILI: 70% productivity (H1), 50% productivity (H2) and 30% productivity (H3)[22].

The base case analysis considered all of these factors in terms of labour costs only. Upper case analyses were also performed to include the impact of lost operating income because of illness. Operating income reflects the contribution of each employee to the global added value, a contribution that is lost when the employee is absent and reduced during periods of post-ILI

Table 1. Sources and calculations of costs for economic evaluation

Cost items	Monetarisation
Direct vaccination programme costs:	
Costs of vaccines and materials	Purchasing prices
Costs of occupational health nurse, doctor and their driver	Time × hourly labour costs
Indirect vaccination programme costs:	
Cost of average time lost by vaccinated employees during administration	Time (3 min) × hourly labour costs
Cost of working days lost due to adverse events	Time × daily labour costs
Indirect ILI costs (excluding impact on operating income):	
Cost of sick leave due to ILI when the employees are not replaced	Number of d × daily labour costs
Cost of sick leave due to ILI when the employees are replaced	Number of d × (daily labour costs of absent employees + daily labour costs of internal or external replacement)
Cost of decreased productivity due to ILI episodes	Number of d × % reduced effectiveness × daily labour costs
Indirect ILI costs (including impact on operating income):	
Cost of sick leave due to ILI when the employees are not replaced	Number of d × (daily labour costs + daily operating income)
Cost of decreased productivity due to ILI episodes	Number of d × % reduced effectiveness × (daily labour costs + daily operating income)

presenteeism. The operating income is calculated by subtracting the cost of sales, selling and administrative expenses to the company's turnover.

For both presenteeism and absenteeism, the human capital approach is used. In one case, the absence (or reduced productivity) is translated into a salary (including taxes) value whereas in the other case the marginal added value of the employee is also considered. In other words, in the latter case, the employee is not only a labour cost but also a contribution to the company turnover.

The net financial benefit of the vaccination programme, in the form of the cost-saving (CS) was calculated using the formula:

Cost-saving per employee =
(cost of ILI in non-vaccinated employees/number of non-vaccinated subjects)—[(cost of ILI in vaccinated employees + cost of vaccination programme)/number of vaccinated subjects].

Using the data derived from these equations, sensitivity analyses were performed to estimate the cost-savings achievable by different rates of vaccination coverage across the workforce.

Statistical analyses were performed as follows: Qualitative and quantitative data from the two cohorts were compared using analysis of variance (ANOVA) or non-parametric tests (Mann-Whitney Wilcoxon for the comparison of two data sets or Kruskal Wallis for comparison of more than two data sets) if ANOVA conditions could not be applied. Qualitative variables were compared using Chi-square tests or Fisher exact tests if conditions for Chi-square tests were not met. Rates of missing data were low, so no data replacement was done. Analyses were performed using SAS software (version 8.2 for Windows).

Results

This study of the health and economic benefits to the employer of a workplace influenza vaccination programme was performed using employees of a Malaysian petrochemical plant owned by Petronas. Out of the total workforce of 3,088, 1,022 volunteered to take part in the study; 504 chose to be vaccinated with the inactivated split influenza vaccine, VAXIGRIP®, leaving 518 in the non-vaccinated cohort.

Demographic data from the two cohorts are shown in Table 2. The study population was mostly male (80%), which was representative of the workforce. Participants in the vaccinated cohort were significantly older than those in the non-vaccinated cohort (33.49 yr vs 31.74 yr, p=0.0009). Other differences between the cohorts included educational level (university and other) and smoking status, with more current smokers among the non-vaccinated cohort (35.90%) than the vaccinated cohort (27.00%, p=0.0021). Chronic medical conditions, including asthma, were more common among the vaccinated cohort than the non-vaccinated cohort. Employees' considered their health to be poor, with mean scores of 3.63 (vaccinated) and 3.84 (non-vaccinated), based on a score of 10 for normal health. However, each

Table 2. Demographic data for vaccinated and non-vaccinated cohorts

		Vaccinated	Non-vaccinated	*p* value
Age, yr	mean (± SD)	33.5 (8.2)	31.7 (7.4)	0.0009
Gender, %	Female	17.5	22.4	0.0485
	Male	82.5	77.6	
Marital status, %	Married	75	72.4	0.0093
	Single or divorced	25	27.6	
Number of people living in the household,	Mean (± SD)	4.55 (2.2)	4.6 (1.7)	NS
Households with children, %		67.86	70.49	NS
Highest education level, %	Secondary	43.91	43.52	0.0008
	University	36.13	27.85	
	Other	16.97	26.50	
Smoking status, %	Currently	26.98	35.91	0.0021
	In past	17.26	11.78	
Sick leave in the past six months, %		33.93	31.88	NS
Chronic medical conditions, %	Any disease	2.78	0.77	0.01481
	Asthma	2.57	0.57	
	Bronchitis	0	0	
	Heart disease	0.2	0.2	
Health status (0–10)	Mean (± SD)	3.63 (0.57)	3.84 (0.49)	<0.0001
Ability to perform usual activities (0–10)	Mean (± SD)	9.10 (0.69)	9.21 (0.67)	0.0111
Previous influenza vaccination, %		2.38	1.74	NS

Table 3. Adverse events reported by the vaccinated cohort within 7 d of vaccination

General symptoms	N	% of vaccinated employees	Local symptoms	N	% of vaccinated employees
Sore throat	38	7.54	Pain	29	5.75
Fever	45	8.93	Tenderness	20	3.97
Tiredness	37	7.34	Redness	9	1.79
Feeling unwell	26	5.16	Swelling	7	1.39
Chills	9	1.79	Bruising	7	1.39
Cough	27	5.36	Itching	7	1.39
Sneezing	28	5.56			
Runny nose	44	8.73			
Generalised itching	8	1.59			
Muscle aches	19	3.77			
Headache	23	4.56			

cohort scored a mean of over 9 out of 10 for ability to perform usual activities.

Post-vaccination adverse event questionnaires were returned by 93.84% (473/504) of the vaccinated cohort, with 32.74% (165/504) reporting at least one adverse event within 7 d post-vaccination. As shown in Table 3, the most frequently reported systemic adverse events were fever (45/504), runny nose (44/504) and sore throat (38/504). Pain (29/504) and tenderness (20/504) were the most commonly reported local adverse events. Post-vaccination adverse events resulted in 8.48% (14/165) of subjects visiting their doctor, 0.61% (1/165) visiting the pharmacist and 7.27% (12/165) visiting the work medical centre. Medically certificated sick leave following vaccination was taken by 3.64% (6/165) of subjects, with an average length (± 1 SD) of 1.17 (± 0.41) d.

ILI, sick leave and vaccine effectiveness: The overall rate of ILI was much lower among vaccinated subjects (8.13%) than non-vaccinated subjects (30.31%), giving a vaccine effectiveness of 73.16%. Most employees reporting ILI reported only one episode (78.13% (25/32) of the vaccinated cohort and 77.87% (95/122) of the non-vaccinated cohort). Fewer vaccinated than non-vaccinated subjects reported more than one ILI episode

Table 4. ILI rates among vaccinated and non-vaccinated cohorts

Nº ILI episodes per employee	Vaccinated		Non-vaccinated		Total	
	Nº	%	Nº	%	Nº	%
0	472	93.65	396	76.45	868	84.93
1	25	4.96	95	18.34	120	11.74
2	5	0.99	19	3.67	24	2.35
3	2	0.4	8	1.54	10	.98
Total	504	100	518	100	1,022	100

Table 5. Distribution of reported ILI symptoms

Symptoms	Vaccinated		Non-vaccinated		Total	
	N	%	N	%	N	%
All ILI episodes	41	–	157	–	198	–
Fever	41	100.00	157	100.00	198	100.00
Systemic symptoms	8	19.51	30	19.11	38	19.19
Respiratory symptoms	32	100.00	122	100.00	198	100.00
Chills	0	0.00	2	1.27	2	1.01
Muscle aches	0	0.00	5	3.18	5	2.52
Runny nose	34	82.93	91	57.96	125	63.13
Sore throat	41	100.00	157	100.00	198	100.00
Cough	20	48.78	83	52.87	103	52.02
Hoarse voice	4	9.76	12	7.65	16	8.08
Headache	8	19.51	23	14.65	31	15.66

during the follow-up period (Table 4): 0.99% (5/504) of vaccinated subjects reported two ILI episodes, compared with 3.67% (19/518) of non-vaccinated subjects. Vaccination against influenza resulted in four times fewer subjects reporting two or three ILI episodes during the follow-up period (Table 4). On average, the sick leave duration was significantly lower in the vaccinated group compared to the non-vaccinated group: 3.00 (± 0.98) d vs 4.22 (± 1.39) ($p<0.0001$). Similarly, vaccinated subjects reported being well again after 5.37 (± 0.58) d of ILI symptoms, compared to 5.80 (± 0.85) ($p=0.0030$). Meaning that when back at work after absence, vaccinated and non-vaccinated employees felt unwell during an average of 2.37 d and 1.58 d, respectively.

Rates of ILI were similar during each two-month segment of the follow-up period: 2.38–2.98% among vaccinated subjects and 9.85–10.42% among non-vaccinated subjects.

As shown in Table 5, fever and respiratory symptoms were reported in all cases of ILI. Other symptoms included sore throat, runny nose, cough and headache. The frequency of reporting of these symptoms was similar between the two cohorts. Visits to the doctor because of ILI were reported by 97.56% of the vaccinated cohort and 99.36% of the non-vaccinated cohort. Furthermore,

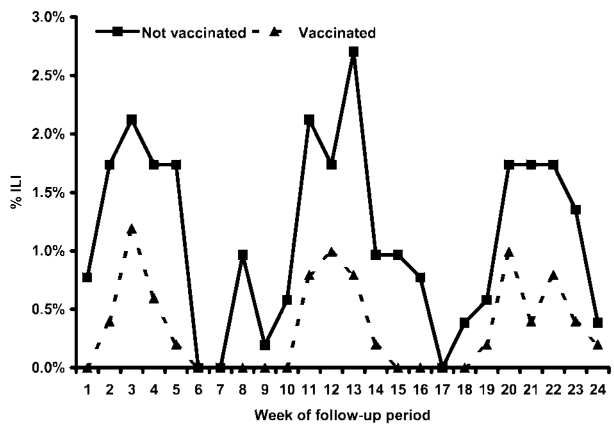

Fig 1. Occurrence of ILI episodes during the post-vaccination follow-up period.

sick leave was reported less often by vaccinated employees (58.54%) than non-vaccinated employees (71.34%), although this difference was not statistically different. However, duration of fever, time until well again and duration of sick leave were all significantly longer among the non-vaccinated cohort compared with

Table 6. Costing of ILI and vaccination programme impact on the two cohorts—base case excluding operating income. Costs were calculated both without and with costs associated with replacement of employees absent because of ILI

	Cost of vaccination programme[a] (US$)	Cost of absenteeism + presenteeism (US$)[b] H1[c]	H2[d]	H3[e]
No replacement				
Total cost–vaccinated employees (n=504)	6,645	7,165	8,895	10,625
Total cost–non-vaccinated employees (n=518)	0.000	34,932	40,054	45,221
Cost per vaccinated employee	13.20	14.20	17.60	21.10
Cost per non-vaccinated employee	0.00	67.30	77.30	87.30
Cost-saving per vaccinated employee		39.90	46.50	53.03
Replacement				
Total cost–vaccinated employees (n=504)	6,645	11,736	13,466	15,196
Total cost–non-vaccinated employees (n=518)	0.000	62,023	67,190	72,357
Cost per vaccinated employee	13.20	23.29	26.72	30.15
Cost per non-vaccinated employee	0.00	119.74	129.71	139.69
Cost-saving per vaccinated employee		83.26	89.81	96.35

[a]cost of vaccines + administration costs , [b]because of ILI symptoms (in both groups) and because of time lost while receiving the vaccine and because of vaccine-associated adverse events (vaccinated group only), [c]H1: productivity rate with ILI symptoms=70%, [d]H2: productivity rate with ILI symptoms=50%, [e]H3: productivity rate with ILI symptoms=30%.

Table 7. Costing of ILI and vaccination programme impact on the two cohorts—upper case including operating income. Costs were calculated both without and with costs associated with replacement of employees absent because of ILI

	Cost of vaccination programme[a] (US$)	Cost of absenteeism + presenteeism (US$)[b] H1[c]	H2[d]	H3[e]
No replacement				
Total cost – vaccinated employees (n=504)	12,009	93,767	116,450	139,132
Total cost – non-vaccinated employees (n=518)	0	488,907	555,116	621,324
Cost per vaccinated employee	23.80	186.00	231.00	276.00
Cost per non-vaccinated employee	0.00	943.80	1,071.60	1,199.50
Cost-saving per vaccinated employee		734.00	816.80	899.70
Replacement				
Total cost – vaccinated employees (n=504)	12,009	43,165	65,847	88,530
Total cost – non-vaccinated employees (n=518)	0	153,584	219,792	286,000
Cost per vaccinated employee	23.80	85.64	130.65	175.65
Cost per non-vaccinated employee	0.00	296.49	424.31	552.12
Cost-saving per vaccinated employee		187.02	269.83	352.64

[a]cost of vaccines + administration costs, [b]because of ILI symptoms (in both groups) and because of time lost while receiving the vaccine and because of vaccine-associated adverse events (vaccinated group only), [c]H1: productivity rate with ILI symptoms=70%, [d]H2: productivity rate with ILI symptoms = 50%, [e]H3: productivity rate with ILI symptoms=30%.

the vaccinated cohort ($p<0.0197$). Illness experienced by another household member during the study was uncommon (less than 5% of subjects reported this). However, influenza infections experienced by household members other than the employee were reported twice as often by non-vaccinated subjects (4.02%) as by vaccinated subjects (2.06%; $p=0.0017$).

Based on sick leave data, vaccine effectiveness was calculated to be 77.98%, i.e. vaccination avoided absenteeism in 77.98% of cases.

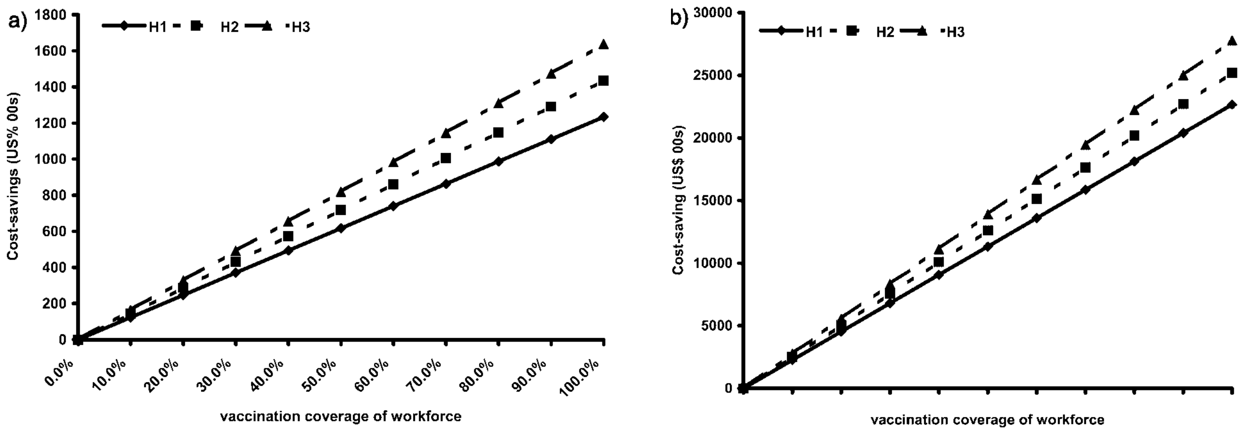

Fig. 2. Impact of variation of coverage rate among all employees on the annual total cost-savings using labour costs only (a) or including operating costs (b). H1: 70% normal productivity; H2: 50% normal productivity; H3: 30% normal productivity.

Over the follow-up period, three peak periods of ILI were reported (Fig. 1). These corresponded to wk 2–5 (end of April–early May), 11–13 (early July) and 21–23 (mid–late September). Similar observations were made for rates of systemic, especially fever, and respiratory symptoms associated with ILI (data not shown).

Economic evaluation: The cost-benefit evaluation of workplace vaccination was performed from the employer's perspective using national statistics, data obtained from the company's human resources department and web site (http://www.petronas.com.my). Results are presented in US dollars (US$) based on the 2001 exchange rate of US$ 1=3.80 Malaysian Ringgits (MYR).

The costs of vaccination and absenteeism/presenteeism because of ILI are shown in Table 6 (base case, without operating income) and Table 7 (upper case, with operating income). Operating income was calculated to be an average of US$ 766.30 per employee per day.

Cost-savings without replacement of the absent worker: based on the data in Tables 6 and 7, the individual cost-savings (ICS) per vaccinated employee was calculated. In the conservative case that ILI resulted in a 30% decrease in performance (H1) because of ILI, workplace vaccination against influenza saved the employer US$ 734 per employee when costs of vaccination, absenteeism and presenteeism were considered, including both labour and operating costs, based on an initial investment of US$ 23.80 per vaccinated employee. Greater reductions in employee efficiency were associated with incremental increases in cost-savings.

The preceding data were obtained based on Petronas' policy of not replacing employees absent because of sick leave. However, when questioned, absent employees claimed that they had been replaced. In order to determine the effect of replacing employees absent because of ILI, cost-saving calculations were performed including costs associated with replacing the absent worker. In the case of replacing the absent worker, ICS values excluding operating income were between US$ 83.26 and US$ 96.35 (Table 6). When operating income was included, ICS values were between US$ 187.02 and US$ 352.64 (Table 7). In both cases, reductions in employee efficiency were associated with incremental increases in cost-savings.

Sensitivity analyses were performed to estimate the effects of vaccination programme coverage on cost savings. As shown in Fig. 2, vaccination of all 3,088 employees could save up to US$ 164,000, excluding operating income. Including operating income, full workforce vaccination could save the employer over US$ 2,500,000.

Discussion

While vaccination of people at risk of severe complications from influenza infection (i.e. the elderly and those with underlying chronic medical conditions) is widely accepted—even recommended—and practised, the potential benefits of vaccinating healthy working adults are not so well recognized[6, 19, 22–28]. The present study was designed to determine whether workplace vaccination against influenza would confer health and economic benefits to Petronas, at a Malaysian petrochemical plant, particularly for the employer seeking to reduce financial losses that occur because of absenteeism and decreased work productivity (presenteeism) associated with influenza infections.

One major strength of the study is the design for ensuring 'real-life' conditions for the research. This pragmatic approach specifically answers the study objectives and provided the employer with useful and convincing information, directly from its own workforce.

Biases that may be argued, such as the voluntary self-selection of the subjects in each of the groups, the ILI definition based on their declaration, the employee-reported absenteeism/presenteeism, are also key factors that differentiate the study from a randomized clinical trial. Questionnaires were regularly administered to the patients by the staff from the occupational health centre of the company, maximising the accuracy of the patient recall. In similar studies, employees have been given diary cards in order to avoid any missing data due to recall.

Demographically, the two cohorts were found to be different in several characteristics that may be explained by either the pragmatic study design or the statistics. The high percentage of males in the study was representative of the whole workforce. The age difference between the two cohorts was statistically significant, but probably as a result of the large sample size rather than any factor likely to affect the results of the study. This was probably true of other factors also. Differences were also observed in the percentage of subjects educated to university or 'other' level. However, the nature of 'other' was not clear, so conclusions about these differences cannot be drawn.

Study subjects rated themselves as having low health status. However, they also rated themselves as being able to perform their usual tasks and less than 4% reported chronic medical problems. Therefore, the low health status should be considered in the wider context of normal function and reported health problems.

Overall, socio-demographic differences and similarities between cohorts also reflected the 'real-life' conditions of the study, allowing the interpretation of health and economic outcomes with limited bias.

Just 6 of the 504 vaccinated employees (3.64%) were absent from work because of vaccine-related adverse events, with a mean duration of sick leave of 1.17 d. Published rates of post-vaccination adverse effects vary considerably with the definition of 'adverse events' used in this study. Rates between less than 15% for systemic reactions (including fever, myalgia, etc) and up to 65% for local reactions (acute inflammation at the point of injection) have been reported[5, 11, 23, 29]. In the present study, the rate of adverse events reported following VAXIGRIP® was 32.74%, well within the published range.

ILI was reported to be the principal cause of sick leave at this particular petrochemical plant. Workplace vaccination with the VAXIGRIP® vaccine reduced rates of ILI (8.13% vs 30.31% in the non-vaccinated cohort), and associated sick leave was reduced by more than a day per episode, on average. Non-vaccinated employees were four times more likely than vaccinated employees to experience two or three episodes of ILI during the six-month follow-up period. Thus, the health benefits of workplace vaccination against influenza in this case are clear.

The economic implications of an employer-sponsored workplace vaccination programme against influenza were studied in several ways, all of which demonstrated a clear return on investment. The accuracy of the economic analyses was maximised by calculating labour costs individually for each educational level. However, operating income was calculated as an average per employee, as no data were available for operating income per educational level.

Presenteeism—workers being at work after ILI but operating at reduced efficiency—was included in all economic calculations. Levels of reduced efficiency will vary between employees, partly dependent on the severity of ILI. Calculations were performed using three hypothesized efficiency levels, 70% (H1), 50% (H2) and 30% (H3) of normal. Presenteeism is not a common factor in economic calculations, having emerged as a factor of health and productivity in the 1990s[9]. Influenza, along with stress, colds, allergy and asthma, and musculoskeletal pain are considered to affect productivity more than problems such as depression, fatigue, substance abuse and poorly managed medical conditions[9]. However, reduced efficiency may have a significant impact on cost-savings, especially when operating income is considered, as shown here and by Morales and *et al.*[11].

During the follow-up period, employees reported that they were replaced during their absence, whereas the human resources department reported that they were not. It is possible that colleagues fulfilled the absent worker's function, rather than the company employing outside, temporary replacements. Because of this ambiguity, cost-benefit analyses were performed considering both replacement and non-replacement of the absent employee, assuming that the person temporarily replacing the sick employee provided the same level of productivity (i.e. operating income) as the absent employee.

The actual cost-savings per vaccinated employer varied depending on whether labour costs only, operating costs or costs of replacing the absent worker were included. However, in each case, paying for the vaccination of healthy adult workers against influenza resulted in cost-savings for the employer. Interestingly, including replacement costs had opposite effects on cost-savings, depending on whether or not operating income was included in the calculations. In the absence of operating costs, replacement approximately doubled the cost-savings resulting from workplace vaccination. However, when operating costs were included, cost-savings were up to four times greater when absent workers were not replaced, which was the situation described by the company's human resources department. The reasons for these differences are unclear and are probably specific to this particular company. For example, in the recently published study by Morales *et al.* on a workplace vaccination campaign against influenza in a Columbian bank[11], the bank operated a policy of non-replacement for sick leave of less than 20 d duration. In this case, including operating income in cost-savings calculations increased savings 10 to 15 times. Thus, it is important to perform these types of analysis for each company where such a programme is being considered, rather than make generalised assumptions.

The results of sensitivity analyses indicate that the company could make cost-savings of up to 2.5 million US dollars by implementing a workplace vaccination programme against influenza that covered the whole workforce. However, this extrapolation should be interpreted cautiously because the analyses were done assuming that all other factors, notably rates of transmission of influenza and programme costs, were unaffected by vaccination coverage. Further study would be needed for accurate, real-life evaluation of the impact of coverage on cost-savings.

The results of this study demonstrate the clear health and economic benefits of a workplace vaccination programme against influenza sponsored by the employer, a Malaysian petrochemical company. The financial benefits of such a programme are clear, whether taking into account labour costs alone or including operating income too. Sensitivity analyses demonstrate that the financial benefits will increase proportionally to vaccination coverage within the company. The results found are consistent with previous studies performed worldwide on the economic and medical benefits of influenza vaccination among the workforce, regardless of the industrial sector, the company size and the country location. Findings may be extrapolated to other countries from either temperate or tropical regions. Indeed, focusing on Asian-Pacific temperate countries, Cohen *et al*. concluded that influenza vaccination created cost savings of 34.5 US$ per vaccinated employee at an Australian mining and quarrying company[30].

This Malaysian study adds to the growing body of data demonstrating the health and economic benefits of vaccinating healthy, working adults against influenza.

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Appendix:

The formulas for absenteeism and presenteeism were as follows:

- for employees who were replaced during their absence:
  [LC (SL d*daily LC) + replacement costs] + H_{RP}* [LC (RP d*daily LC) + OI]
- for employees who were not replaced during their absence:
  [LC (SL d * daily LC) + OI] + H_{RP} * [LC (RP d*daily salary) + OI]

with:

LC=Labour costs: salary costs of the sick employee, as paid by the employer (i.e. including all taxes).

SL=Sick Leave: d of absence from work for the sick employee.

Replacement costs: costs, as paid by the employer for a temporary contract-person, or for extra-hours paid to another employee, etc.

H_{RP}=Hypothesis of reduced productivity when the employee is back to work but still feeling unwell due to ILI. The assumption in base-case is 30% of reduced productivity (H=50% and 70% have also been tested in sensitivity analyses).

RP=Reduced Productivity: refers to the days following the absence, during which the employee is still feeling unwell but is back to work and therefore has a reduced productivity.

OI=Operating Income (see definition) as the work is partially done when the employee is back to work or not done during the absence.

For scenarios assuming labour costs only, the same formulas were applied but with removal of the 'OI' component.