

SHORT REPORT

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Cost analysis of measles in refugees arriving at Los Angeles International Airport from Malaysia

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ABSTRACT

Background

On August 24, 2011, 31 US-bound refugees from Kuala Lumpur, Malaysia (KL) arrived in Los Angeles. One of them was diagnosed with measles post-arrival. He exposed others during a flight, and persons in the community while disembarking and seeking medical care. As a result, 9 cases of measles were identified.

Methods

We estimated costs of response to this outbreak and conducted a comparative cost analysis examining what might have happened had all US-bound refugees been vaccinated before leaving Malaysia.

Results

State-by-state costs differed and variously included vaccination, hospitalization, medical visits, and contact tracing with costs ranging from \$621 to \$35,115. The total of domestic and IOM Malaysia reported costs for US-bound refugees were \$137,505 [range: \$134,531 - \$142,777 from a sensitivity analysis]. Had all US-bound refugees been vaccinated while in Malaysia, it would have cost approximately \$19,646 and could have prevented 8 measles cases.

Conclusion

A vaccination program for US-bound refugees, supporting a complete vaccination for US-bound refugees, could improve refugees' health, reduce importations of vaccine-preventable diseases in the United States, and avert measles response activities and costs.

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cost; measles; outbreak; refugee; vaccination

Introduction

The United States Refugee Admissions Program offers resettlement opportunities to approximately 70,000 refugees annually.¹ After the US Department of Homeland Security grants individuals refugee status overseas, the US Department of State brings US-bound refugees to the United States for resettlement.² While overseas, US-bound refugees must undergo legally required medical examinations by panel physicians, according to guidelines written by the Division of Global Migration and Quarantine (DGMQ), Centers for Disease Control and Prevention (CDC).^{3,4} By regulation, exams focus on diagnosis and treatment of health conditions that prevent permanent migrants from entering the United States, e.g., tuberculosis.⁵ Unlike immigrants, refugees are not required to have vaccinations before immigrating, slightly increasing the risk of vaccine-preventable disease import.⁶ The costs of refugee medical care both overseas and for approximately the first year in the United States are paid for by the US government.⁷ The US government provides funding to the International Organization for Migration (IOM) to provide health services for US-bound refugees including panel physician activities in

several countries that send a large number of refugees to the United States.

On August 24, 2011, 31 persons from a group of 1,531 Burmese refugees resettling to the United States from Kuala Lumpur, Malaysia (KL) arrived at the Los Angeles International Airport.^{8,9} The index case, a 15 y old unvaccinated male, developed fever and a rash in Malaysia, but was not diagnosed with measles until after visiting 2 emergency rooms in the United States.^{8,9} The index case had exposed travel companions and others, including US-bound refugees who had lived in the same community in Malaysia.⁸ KL had ongoing measles outbreak issues that time.⁸ Burmese refugees in Malaysia live in a wide array of independent housing arrangements in an urban setting.¹⁰ In comparison to large refugee camp settings observed in other countries, urban refugees probably lacked access to internationally-supported health care and vaccination programs. After arrival in the United States, the index case and family stayed in California until the entire family was measles-free, while others dispersed to multiple states, including California, Maryland, Massachusetts, New Hampshire, North Carolina, Oklahoma, Texas, and Wisconsin

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(Reference 8 also lists Washington, but they were not included in this study).^{8,9}

Public health investigations were initiated by most states that received refugees from this cohort and in Malaysia for US-bound refugees who had not yet departed.⁸ DGMQ experts coordinated the domestic response with state Refugee Health Coordinators and local health departments (HD) in the United States.⁸ To ensure no additional importation of measles cases among US-bound refugees from Malaysia, during September and October 2011, CDC issued vaccination and surveillance recommendations for US-bound refugees.⁸ As a result of the investigation, IOM Malaysia and US HDs identified a total of 9 measles cases, including 2 cases among unvaccinated US-bound refugees who had not yet departed Malaysia, 4 cases among unvaccinated refugees that had already arrived in the United States, and 3 cases among unvaccinated US citizens who had contact with or sat in the same area of the aircraft as the index case.^{8,9} More details about the outbreak can be found in the original outbreak report.⁸

This article reports results of a cost analysis of the domestic and international outbreak responses, including contact investigations, vaccinations, and treatments undertaken between August 24, 2011, and October 31, 2011. Cost data were obtained from domestic and Malaysia surveys conducted by DGMQ. Also, we report the results of a comparative cost analysis that estimated costs for a hypothetical program in which all of the US-bound refugees in Malaysia were vaccinated before departure and the expected number of measles cases with the preventive vaccination program.

Results

The domestic survey showed that state HDs incurred costs for the following activities: contact tracing, medical assessments for evidence of measles immunity, and where appropriate, offered measles mumps and rubella (MMR) vaccine to individuals exposed to confirmed measles patients. Total

Table 1. Cost of response to measles in refugees arriving at Los Angeles International Airport from Malaysia for each state.

Cost Categories	# Refugees	# Patients	# Staff	Event Costs ¹	
				Baseline	Range [min – max]
Texas	2	0	21	\$2,295	\$2,295
New Hampshire	3	0	4	\$692	\$692
North Carolina	5	1	17	\$8,847	\$8,847
Maryland	5	2	15	\$15,398	\$15,398
Oklahoma	4	0	10	\$621	\$621
California	4	4 ³	50	\$35,115	\$35,115
Wisconsin ²	4	0	N/A	\$2,108	[\$621 - \$4,744]
Massachusetts ²	4	0	N/A	\$2,108	[\$621 - \$4,744]
Total	31	7		\$67,184	[\$64,210-\$72,456]

Notes:

¹Event costs include costs of labor, measles testing, vaccination, outpatient treatment and hospitalization.

²Wisconsin and Massachusetts are assigned an average per-refugee costs of Texas, New Hampshire, North Carolina, and Oklahoma multiplied by numbers of refugees assigned to Wisconsin and Massachusetts, respectively.

³One of them was the refugee index case. All other 3 cases were non-refugees.

Table 2. Cost analysis of the domestic and international response to measles in refugees arriving at Los Angeles International Airport from Malaysia.

		Baseline	Range [min – max]
Domestic Costs	Costs of labor, measles testing, vaccination, outpatient treatment and hospitalization (a)	\$67,184	[\$64,210-\$72,456]
Malaysia Costs	Costs for rescheduling US-bound refugees for later flights, vaccinating resettling refugees, treatment of one hospitalized case, and etc. ^{1,2} (b)	\$70,321	\$70,321
Total measles event and treatment costs (a)+(b)		\$137,505	[\$134,531-\$142,777]
Measles event and treatment costs per case: ((a)+(b))/9 cases		\$15,278	[\$14,948-\$15,864]

Notes:

¹Costs includes vaccination costs of 1,500 refugees reported by IOM Malaysia (\$19,248).

²Transportation costs for hospital visits at Kuala Lumpur were not included because the costs were out-of-pocket payments. Additional \$18,564, \$26 per round trip multiplied by 714 families (1,500 refugees divided by 2.1), are expected for the transportation costs. Some refugees may have made multiple trips, while some made none.

domestic state costs for the measles investigation and treatment ranged from a low of \$621 in Oklahoma to a high of \$35,115 in California (Table 1) and totaled \$67,184 (range: \$64,210-\$72,456).

The Malaysia survey results showed that IOM Malaysia conducted the following response-related activities for refugees slated for relocation to the United States: (1) Enhanced measles screening and administration of MMR vaccine to 1,500 US-bound refugees, (2) Administration of 650 pregnancy tests to women to ensure they were eligible to receive MMR vaccines, (3) Full clinical medical exams for 170 US-bound refugees whose medical certificates required for travel expired during the measles outbreak response, (4) The monetary penalties incurred for airline rebooking for 1,020 US-bound refugees who had to reschedule their originally planned flights, (5) Care of 2 refugee children diagnosed with measles, one of whom was hospitalized.

Total costs associated with outbreak response reported by IOM Malaysia were \$70,321 (Table 2). During September and October 2011, IOM Malaysia reported that their costs to reschedule refugees for later flights were over \$32,000 and that an additional \$19,248 was spent on vaccinating 1,500 refugees. The total of domestic and IOM Malaysia costs were \$137,505 (range: \$134,531 - \$142,777). The ratio of event costs to measles cases resulted in a cost of \$15,278 for each measles case; \$137,505 divided by 9.

Pre-departure vaccination of the 31 refugees who traveled on the same plane as the index case would have cost \$398 (\$12.83 per person) in addition to the \$19,248 reported by IOM Malaysia, for a vaccination total of \$19,646 (Table 3). Assuming the MMR vaccine was 93% effective,¹¹ vaccination of the entire group of 1,531 refugees (1,500 plus 31 travelers) before the measles event occurred would have reduced this number of measles cases from 9 to 0.6 (9×.07). The ratio of the cost of vaccinating the 1,531 refugees to the reduced numbers of cases that would occur

Table 3. Cost of vaccination of all 1,531 refugees before measles outbreak and expected several cases prevented.

Total Cost of vaccination (a): \$12.83 ¹ × 1,531 refugees	\$19,646
Number of measles cases prevented ² (b): 9 cases – (9 cases × 93% reduction)	8
Cost per prevented case (a/b)	\$2,456

Notes:

¹Per-person cost of MMR vaccination as reported by IOM Malaysia for 1,500 (no refugee out-of-pocket costs included) was \$12.83.

²We assumed 93% reduction in number of cases by vaccinating all 1,531 refugees.

after vaccination would result in \$2,456 of vaccine costs for each of the 8 avoided cases (\$19,646/8).

Discussion

Vaccinating US-bound refugees against measles while overseas would save government funding at all levels (federal, state, and local). Further, overseas vaccination would have prevented substantial morbidity, along with inconvenience, pain, and suffering, to the 9 with measles. This analysis combines both overseas (Malaysia) and domestic costs (HD expenditures) and outcomes (measles cases identified or hypothetically prevented in cost comparison analysis) because there was one predominant payer; the federal government provided all overseas and most domestic funding (Appendix C). The response costs for US-bound refugees in Malaysia were financed by the US Department of State through contracts with IOM (Communications with CDC and IOM Malaysia). The costs of the state HDs were financed to a great extent by federal grants and other funding mechanisms. Newly arrived refugee health care was paid for by the federal government because the refugees had not been in the United States long enough to be eligible for private insurance.^{7,12} The adult infected in the United States was a federal government employee with job-based insurance,⁸ and the persons immunized by state HDs received vaccines purchased with government funds.

There were some limitations we were unable to address. One was the lack of data from 2 states and partial data from California. We tried to address this issue by conducting a sensitivity analysis and imputation. Also, wages were not solicited in the survey and estimates might not fully reflect actual wages, although we used state-specific comprehensive survey data for estimation. Another was not including an overtime component, though some people worked additional hours on the response, or on other tasks that went uncompleted because of the response. Further, some health departments might have had to delay or not engage in other important public health activities because their time was used in responding to this measles event. A third limitation was the lack of available information regarding actual hospitalization cost and the inability to estimate a reliable average hospitalization cost.

The fourth limitation was the inability to complete a full economic evaluation without a denominator population. Published domestic analyses of vaccines' cost-effectiveness define denominator populations explicitly, e.g., a birth cohort or a group diagnosed with a disease.^{13,14} Because

US-bound refugees are a small set of all refugees from Malaysia, live in an urban setting, and came from a wide variety of geographic areas in the years before domestic resettlement, their true population was unknown. Similar problems would exist among refugees arrived from a camp, e.g., Dadaab, the largest refugee camp in Africa. In the camps, US-bound refugees are a tiny portion of all camp residents, so any analysis of vaccination-related costs and benefits would need to include highly mobile populations not bound for the United States.

Another limitation that prevented a full economic evaluation of the benefit of a routine preventative vaccination program for US-bound refugees was that the probability of a measles outbreak within a similar refugee cohort is not known. Thus, while both the cost of the outbreak (\$137,505) and the hypothetical cost of an alternative scenario in which the same population was fully vaccinated before departure (\$19,646) can be calculated, it is not possible to directly compare these costs without quantifying the probability that such an outbreak would occur in another cohort of unvaccinated refugees.

Despite the limitations, understanding the costs associated with responding to measles cases after they are identified is important information for the pursuit of finding resources to expand overseas refugee vaccination programs. The index case sparked the outbreak was 15 y old and was neither vaccinated nor immune from having measles at a younger age when infection is more common.^{12,15} Between January 1 and May 29, 2015, 173 persons contracted measles after contact with a single index case at a theme park in California.¹⁶ Almost all of the 173 persons were unvaccinated, and the majority of cases were in California where low vaccination rates have been documented in some communities.¹⁷

Almost all domestic measles cases were introduced from either unvaccinated citizens traveling overseas and bringing illness back or foreign travelers introducing measles to domestic communities. In the United States in 2011, 222 measles cases were identified, and of those 200 were associated with importations from other countries.¹⁸ Further, other recent studies document the costs of measles outbreaks in the United States^{12,19-21} and one of these publications includes the costs of response to another refugee-associated measles case in Kentucky.¹² The reported results of this study indicate that vaccinating US-bound refugees overseas would contribute to a reduction in the domestic medical and economic burden of measles.

Methods

Perspective

The analytic perspective is that of federal, state, and local governments in the United States. The government perspective was chosen because overseas and domestic refugee medical and living expenses were solely borne by a variety of government entities, and funding to IOM Malaysia for the measles outbreak response for US-bound refugees in Malaysia was provided by the US Department of State (Appendix C).

Costs were not discounted because all expenditures took place within a few months and long-term measles consequences were not included in the analysis. All costs were reported as 2011 US dollars since the duration of this analyses covered the period between August 24, 2011, and October 31, 2011.

Collection of measles response costs

To estimate response costs, a short survey (Appendix A) was completed by HDs in each state that received refugees from Malaysia and IOM Malaysia staff working with US-bound refugees. The data were analyzed to determine costs per-state, per-refugee, and in Malaysia. A 10-question survey was sent to the states that received refugees from Malaysia: California, Texas, North Carolina, Maryland, New Hampshire, Massachusetts, Oklahoma, and Wisconsin. States that did not receive refugees with measles answered only survey questions that were applicable to their situation. IOM Malaysia staff worked in collaboration with CDC to answer a 12-question survey.

Analysis of survey responses

CDC received fully completed surveys from Texas, New Hampshire, North Carolina, Maryland, and Oklahoma. California provided most of the information requested including total numbers of employees and their titles, but did not provide all of the detail requested for staff and hours. Therefore, the numbers of employees in each title (e.g., registered nurses or analysts) and labor hours in California were estimated (Appendix B). Wisconsin and Massachusetts did not provide enough information to estimate their costs. Since there were no cases among refugees in these states, the average of per-refugee costs for Oklahoma, Texas, and New Hampshire (i.e. 3 states without measles patients) was multiplied by 4 (i.e., the numbers of refugees relocated to each state) as a baseline estimate (\$527 per refugee or \$2,108 for each state). We conducted a sensitivity analysis using the minimum and maximum per-refugee costs from the 3 states (\$621 - \$4,744 per event for each state).

Cost calculation

Domestic Costs by state

Employee salaries were determined by matching state-reported titles with the same or similar titles in the Occupational Employment Statistics (OES).^{12,22} Often the state-reported employee title was the same as the OES title, e.g., epidemiologist, registered nurse, etc. In other cases, substitutes were chosen after speaking with states about job tasks, e.g., the state-reported title of a resettlement facilitator was assigned the OES wages for “eligibility interviewers, government programs.” In some cases, wages were averaged across a couple of OES titles. For example, the state-reported titles of section director and area chief became an average of the OES wages for medical and health services managers and medical scientists except for epidemiologists.

OES wage data 2011²² were used because the data are results of large surveys by the Bureau of Labor Statistics, and OES survey results are more representative of labor valuation than any

individual employee’s wage. Wages were set from state data and were adjusted to become salaries by adding 35% for benefits and taxes.^{12,23} State-by-state labor costs were estimated by multiplying the salaries of each title times the reported time spent on the HD response.¹²

Other domestic costs associated with the outbreak response included measles testing, vaccination, and immunoglobulin costs incurred during contact investigations. While labor costs to conduct these activities were already considered in the wages, we used the minimum allowable billing charge for measles tests (\$87) from the Physicians’ Fee and Coding Guide to estimate what HDs would pay.²⁴ Costs of vaccinations included the cost of vaccines and vaccine administration fees. The 2011 Vaccines for Children price of MMR vaccine of \$18.99 was used as the cost of the vaccine per dose.²⁵ We applied state-specific Medicaid vaccine administration fees using internal data from Immunization Service Division, CDC. The fees vary from \$3.00 to \$17.25 per dose.²⁶ Maryland also reported spending \$87 for immunoglobulin treatments of individuals exposed to measles patients.

The last cost category was for 3 hospitalizations, 2 in the United States and one in Malaysia. The hospitalization costs in Malaysia are described in the next section. In the United States, North Carolina reported that one hospitalized case costed \$2,395 based on hospital billing records. California did not report costs for the measles index case who was hospitalized. California hospitalization costs were assumed to be 50% higher than North Carolina’s (an estimate of \$3,593), by applying the ratio of hospital-adjusted expenses per inpatient day at state/local government hospitals in North Carolina to the expenses in California from the 2011 American Hospital Association Annual Survey.²⁷ There were also outpatient treatment costs for 2 domestic measles patients paid by the government. The outpatient treatment cost estimate of \$688 was the average of results from 2 publications adjusted to 2011 dollars using the Bureau of Labor Statistics inflation calculator.^{12,19,28} This treatment cost of \$1,376 ($\688×2) was added to the Maryland state cost estimate.

Domestic costs (labor, measles testing, vaccination, outpatient treatment, and hospitalization) were totaled for each state, then across states for a total domestic cost of the measles investigation event.

Costs in Malaysia

IOM Malaysia reported detailed labor and resource costs spent to prevent further measles cases among US-bound refugees in 2011 US dollars: staff numbers and titles with salary and hours worked; supplies, overhead (e.g., IT, phone calls), and hospitalizations; and numbers of activities (e.g., phone calls, tests). IOM Malaysia also engaged in activities including measles screening, MMR administration, pregnancy testing, additional medical exams, flight rebooking, and treatment of 2 children with measles.

Total Cost

Total measles investigation costs were calculated by adding domestic and Malaysia total costs. A total cost per measles case was calculated by dividing total measles response event costs by 9; all measles cases during this outbreak in the United States and Malaysia.

Cost Analysis Measures

Two measures were developed:

- The first measure was an estimate of the total measles response costs (US + Malaysia).
- The second measure was a ratio of total costs to cases identified in the measles investigation.

Comparative cost analysis

We assumed a hypothetical vaccination program, which provided vaccination to all refugees designated to arrive in the United States during the summer of 2011 before leaving Malaysia. The cost of a hypothetical program was estimated by adding \$398 for vaccinating the 31 refugees who traveled on the same plane as the index case (\$12.83 per person × 31 persons) to \$19,248 reported by IOM Malaysia to vaccinate 1,500 refugees. The estimate of \$12.83 per vaccinated person was based on the data provided in the Malaysia survey. We assumed that vaccination effectiveness would be 93% for the first dose based on the literature.¹¹ We estimated the number of averted cases associated with pre-departure vaccination of all US-bound refugees by multiplying 93% effectiveness by 9 cases. Then we divided the overseas vaccination cost estimate by the number of cases averted to estimate the cost per case averted with the hypothetical program. All analyses were performed in Microsoft Excel.

Conclusion

Partly as a result of this event, CDC and the Department of State have developed a vaccination program for US-bound refugees, with the hope of reducing costs and morbidity associated with vaccine-preventable diseases. More complete vaccination of refugees would both protect the health of refugees and prevent domestic entry of vaccine-preventable diseases, thereby avoiding measles event response and treatment costs.

Disclosure of potential conflicts of interest

No potential conflicts of interest were disclosed.

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Appendix A

Domestic Survey

1. What types of drugs or treatment are prescribed for this type of illness? Please answer for a typical pediatric or adult patient as appropriate. ___ medications ___ intravenous fluids ___ other, specify: _____
2. What is the average cost of pediatric (adult) hospitalizations per day for a communicable illness at the facility this patient was sent to? _____
3. Describe the activities implemented as part of the response:

4. How many personnel were involved? _____
5. What was their job classification and how many hours did each work on the response?

Count and describe tasks associated such as number of phone calls made as part of the follow-up; numbers of meetings; distances traveled; types of transportation (own care, government vehicle, public transportation), supplemental expenditures such as travel, per diem, etc.

6. How many contacts were identified? _____
7. How many were tested for measles with serology? _____
8. How many contacts were vaccinated? _____
9. How many contacts had illness detected? _____
10. How many contacts developed measles? _____

Malaysia (Kuala Lumpur) Survey

1. Describe the activities implemented as part of the response:

Count and describe tasks associated with the event such as numbers of phone calls or meetings; distances traveled; types of transportation (own care, government vehicle, public transportation); numbers of doses of vaccine distributed

4. How many cases were identified (measles)
 - a. What treatment was provided for each case?
 - b. Was anyone hospitalized?
 - c. What was the cost of each component of treatment? For example, drugs, physician care, nurse care, hospitalization, etc.
5. How many contacts were identified for each case? _____
6. How many were tested for measles with serology? _____
7. How many refugees were vaccinated? _____
8. How many refugees had illness detected? _____
9. How many refugees developed measles? _____
10. How many refugees were able to keep their original travel plans?
11. How many refugees were rescheduled to fly without an additional full medical exam?
 - a. Were these refugees provided with resources other than a rebooked flight? If yes, what resources?
12. How many refugees had to receive an additional full medical exam?
 - a. How many of these refugees were rebooked on later flights?
 - b. Were these refugees provided with resources other than a rebooked flight and additional medical exam? If yes, what resources?

Appendix B

There were 3 HD groups involved in the California response: Los Angeles California Department of Public Health (LACDPH) that provided nursing staff; LACDPH that provided epidemiology staff; and Long Beach HD staff. The LACDPH nursing group reported 41 staff working in 4 categories of Public Health Nurses, Public Health Nurse Supervisors, Medical Directors, and Assistant Program Specialists. None of the other states reported Assistant Program Specialists, so we assumed there were 5 employees in this category. The other 36 staff were apportioned in the same ratio of staff in title to total staff as North Carolina, the only other state to report all 3 of these categories. The LACDPH epidemiology department reported 5 employees, with 3 research analysts and 2 epidemiologists. Long Beach reported the number of employees in each title. All of the groups reported only total hours for their group, so labor hours were apportioned across each title in the ratio of numbers of employees in those titles.

Appendix C: Payers for each response activity

	Refugees	Non-refugees
Domestic activities		
(1) HDs response activities HDs' labor Measles testing MMR vaccination Immunoglobulin treatment	State and local HDs paid salaries to employees who were involved in the response activities. Refugee health coordinators may be financed mostly by the federal funding and communicable disease control efforts may be subsidized by federal grant money; however, funding sources varied by state.	
(2) Outpatient visits	Federal (RMA) or state (Medicaid) government paid outpatient or inpatient costs to hospitals. Funding sources were varied by state but all costs were covered by the US government.	Health care sectors, such as health insurances and patients, paid outpatient costs to hospitals. (The costs were excluded because of the study perspective.)
(3) Hospitalization		N/A (There were no domestic non-refugee hospitalization cases associated with this measles outbreak.)
Activities related to the US-bound refugees in Malaysia	Federal government (Department of States) paid all response costs for US-bound refugees to IOM for delivering the all services.	N/A (There were no activities for Malaysians in KL during the study period.)

Notes:

HD: Health department

RMA: Refugee Medical Assistance

Data Source: Division of Global Migration and Quarantine (DGMO) and IOM Malaysia internal data.