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A comparative cost analysis of the Vaccination Program for US-bound Refugees

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Abstract

Background—Vaccination Program for US-bound Refugees (VPR) currently provides one or two doses of some age-specific Advisory Committee on Immunization Practices (ACIP)-recommended vaccines to US-bound refugees prior to departure.

Methods—We quantified and compared the full vaccination costs for refugees using two scenarios: (1) the baseline of no VPR and (2) the current situation with VPR. Under the first scenario, refugees would be fully vaccinated after arrival in the United States. For the second scenario, refugees would receive one or two doses of selected vaccines before departure and complete the recommended vaccination schedule after arrival in the United States. We evaluated costs for the full vaccination schedule and for the subset of vaccines provided by VPR by four age-stratified groups; all costs were reported in 2015 US dollars. We performed one-way and probabilistic sensitivity analyses and break-even analyses to evaluate the robustness of results.

Results—Vaccination costs with the VPR scenario were lower than costs of the scenario without the VPR for refugees in all examined age groups. Net cost savings per person associated with the VPR were ranged from $225.93 with estimated Refugee Medical Assistance (RMA) or Medicaid payments for domestic costs to $498.42 with estimated private sector payments. Limiting the analyses to only the vaccines included in VPR, the average costs per person were 56% less for the VPR scenario with RMA/Medicaid payments. Net cost savings with the VPR scenario were sensitive to inputs for vaccination costs, domestic vaccine coverage rates, and revaccination rates, but the VPR scenario was cost savings across a range of plausible parameter estimates.

Conclusions—VPR is a cost-saving program that would also reduce the risk of refugees arriving while infected with a vaccine preventable disease.

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Keywords

US-bound refugees; overseas vaccination; cost analysis

1. Introduction

In fiscal year (FY) 2015, about 70,000 refugees resettle in the United States [1]. Unlike other immigrants, refugees are not required to have any vaccinations before US arrival. Lack of immunity among refugees may cause outbreaks of vaccine-preventable diseases (VPDs) in US communities and lead to significant public health-response costs [2]. To improve the health of US-bound refugees and reduce costs, the US Centers for Disease Control and Prevention (CDC) initiated the overseas Vaccination Program for US-bound Refugees (VPR) in December 2012 [3]. VPR is a collaboration between the US CDC's Division of Global Migration and Quarantine and the US Department of State's Bureau of Population, Refugees, and Migration. The program is implemented mainly by the International Organization for Migration (IOM). For 2012 through 2015, IOM administered vaccines in six countries—Ethiopia, Kenya, Malaysia, Nepal, Thailand, and Uganda. IOM and CDC are expanding VPR to 21 countries for FY 2017 [3]. In addition to administering the recommended vaccines, IOM transcribes valid vaccination records into official documents to share with health departments after refugees arrive.

After arrival in the United States, refugees are covered by either Medicaid or federally funded Refugee Medical Assistance (RMA) for at least 8 months [4]. During this period, vaccines for refugees would be primarily reimbursed through direct or indirect federal payments [4]. The US CDC recommends that refugees undergo a comprehensive medical exam within 90 days after arrival. Vaccines may be delivered at the comprehensive exam or follow-up appointments.

Relative to the baseline scenario, in which all vaccines are delivered after arrival in the United States, VPR is expected to decrease vaccination costs per fully vaccinated individual because vaccination costs are lower overseas compared to costs in the United States. We conducted a comparative cost analysis of fully vaccinating a US-bound refugee according to the Advisory Committee on Immunization Practices (ACIP) recommendations for age, with and without VPR, to estimate cost savings.

2. Data and Methods

We estimated the costs for refugees to complete the relevant age-appropriate, ACIP-recommended vaccination schedule, according to two scenarios: 1) the pre-2012 baseline with no VPR, in which all refugee vaccinations would occur after US arrival ('No VPR' scenario) and 2) the current situation with VPR, and US follow-up to complete recommended vaccination schedules ('VPR' scenario). Under the 'VPR' scenario, refugees received one or two doses of selected vaccines prior to departure and additional vaccines to complete their age-appropriate schedule after resettlement in the United States. All costs were estimated in 2015 US dollars from the US payers perspective [5]. Costs were not

discounted because we assumed refugees would complete age-specific, recommended catch-up schedules [6, 7] within a 1-year time horizon.

We included all age-specific, ACIP-recommended vaccines except influenza in the catch-up schedule in the analyses [6, 7]. To facilitate the analyses, US bound-refugees were divided into four age groups based on the age they were able to start immunization: 1) infant to 4.9 years old, 2) 5–10.9 years old, 3) 11–18.9 years old, and 4) ≥19 years old. VPR provides one to two doses of the following vaccines: hepatitis B (HepB); diphtheria, tetanus, and pertussis (DTP); tetanus, diphtheria (Td); *Haemophilus influenzae* type b (Hib); Pentavalent (HepB-Hib-DTP); oral poliovirus (OPV); and measles, mumps, and rubella (MMR).

Domestic vaccination costs for refugees

We used Medicaid reimbursement rates as the base case since RMA reimbursement rates are similar to Medicaid rates. Because Medicaid beneficiaries aged 0 through 18 years are eligible for the Vaccines for Children (VFC) program [8], base case and lower-bound costs of pediatric vaccines were estimated using the US CDC purchasing costs for the VFC from the 2015 *Pediatric/VFC Vaccine Price List* [9].

Base case costs of adult vaccines were estimated using 2014 MarketScan Medicaid multi-state data, which was adjusted to 2015 prices by using the average change in private sector prices between 2014 and 2015 [9]. The lower-bound estimates were government purchasing rates for the Section 317 Immunization Program for uninsured or underinsured adults [10], and the upper-bound estimates were private sector prices from the 2015 *Adult Vaccine Price List* [9].

We used Current Procedural Terminology (CPT) codes 90460 and 90461 to estimate vaccine administration fees for refugees younger than 19 years old. For adults, CPT codes 90471 and 90472 were used. Estimated vaccine administration fees for Medicaid beneficiaries in 2015 were used for the base case and lower-bound estimates. The upper-bound cost estimate was the midpoint of private sector fee ranges from Healthcare Solutions' *2015 Physicians' Fee & Coding Guide* [11].

Overseas vaccination costs for US-bound refugees

For vaccine costs, we used the weighted average cost per dose by vaccine, using FY 2017 country-specific budgets weighted by the expected number of US-bound refugees from each country and the expected numbers of pediatric and adult vaccines purchased. For program administration costs, we assumed that there were fixed and variable costs. The fixed cost per refugee, which is independent of the numbers of doses given to each refugee, included the office, office overhead, and HepB surface antigen (HBsAg) test costs. The variable costs were estimated per dose delivered, and included staff, staff overhead, and non-vaccine operational costs. The lower-bounds are the first quartile of vaccine and program costs across the budgets of the VPR-implementing countries, while the upper-bounds are the third quartile of budgeted costs. We assumed that per dose and per person costs in FY 2017 budget were equivalent to those costs in 2015.

Estimation of per person costs by scenario

For the 'No VPR' scenario, the number of doses per refugee to achieve full vaccination by age was multiplied by the domestic vaccination cost per dose to estimate domestic vaccination costs per person by vaccine. Per-person vaccination costs by vaccine for each age group were summed to estimate costs of vaccination per refugee.

For the 'VPR' scenario, overseas and domestic vaccination costs were included. For each vaccine provided by VPR, we multiplied the number of doses given per person by the sum of the overseas vaccine and variable program costs per dose. We added estimates for all vaccines required by age group, and added the overseas fixed program cost per person to estimate the total overseas vaccination costs per person. The remaining numbers of doses after arrival were estimated by subtracting the numbers of doses provided by the VPR from the numbers of doses to fulfill the ACIP-recommended schedule by age for each vaccine. Then, we followed the same steps used to estimate domestic vaccination costs under the 'No VPR' scenario to estimate domestic vaccination costs under the 'VPR' scenario.

Because vaccines that are not currently included in VPR incurred the same costs under both scenarios, we separately examined the costs for VPR vaccines (i.e., DTaP/DTP/Tdap/Td, HepB, Hib, IPV/OPV, and MMR) to focus more directly on the relative costs of pre-departure versus post-arrival vaccination costs for US-bound refugees.

Sensitivity analyses

We conducted sensitivity analyses to evaluate the robustness of our results. We performed one-way sensitivity analyses by setting one cost parameter at the lower- and upper-bound estimates while keeping all other parameters fixed at base case values. In addition, we conducted break-even analyses for domestic coverage rates and domestic revaccination rates. For the base case analysis, we assumed all refugees completed ACIP-recommended vaccination schedules after arrival in the United States. However, some refugees might not complete the vaccination schedule after arrival. Also, some refugees might be unnecessarily revaccinated after arrival because some healthcare providers might not consider overseas doses to be valid.

For break-even analysis, we varied the domestic coverage rates between 0% (no domestic vaccination) and 100% (complete domestic vaccination) and identified the coverage rate for which the costs for the 'VPR' and 'No VPR' scenarios were equivalent. We also estimated the numbers of doses of each vaccine received by refugees at the break-even domestic coverage rate. We varied the revaccination rate from 0% (no domestic revaccination) to 100% (none of the doses provided overseas are considered valid in the United States) to investigate the effect of revaccination on vaccination costs.

To perform probabilistic sensitivity analyses (PSA), we used a Monte Carlo Simulation approach to randomly draw input parameters 10,000 times from independent probability distributions to estimate 99% credibility intervals [12]. More details about data and methods are provided in the Appendix.

3. Results

Vaccination costs under the ‘VPR’ scenario were lower than the costs under the ‘No VPR’ scenario across age groups (Table 1). The average full vaccination costs for the ‘No VPR’ scenario were $785.22 per person after weighting by age, while average costs under the ‘VPR’ scenario were $559.30 per person. Thus, the ‘VPR’ scenario saved $225.93 per person compared to the ‘No VPR’ scenario. The implementation of VPR reduced full domestic vaccination costs by 29%. For the VPR vaccines, the costs per person were 56% less for the ‘No VPR’ scenario ($406.66) versus the ‘VPR’ scenario ($180.73) (Table 1). Among the net cost savings of $225.93 per person, 79% ($177.47 per person) is from reduced vaccine costs and the remaining 21% ($48.46 per person) is from reduced vaccine administration costs (Table 2).

The results of one-way sensitivity analyses of net cost savings associated with VPR are shown in Figure 1. Uncertainty in the domestic vaccine administration fee had the largest impact on net cost savings (range: $225.93–$414.51 per person). The ‘VPR’ scenario was less expensive than the ‘No VPR’ scenario across all one-way sensitivity analyses.

When the domestic coverage rates are varied between 100% (base case) and 0%, the net cost savings of the ‘VPR’ scenario compared to the ‘No VPR’ scenario varied from $225.93 per person to −$46.17 per person in Figure 2. At 0% domestic coverage (i.e. if refugees only receive VPR vaccines without additional vaccination after US arrival), the resulting net cost of $46.17 per refugee is equivalent to the average overseas vaccination costs per refugee. The break-even domestic coverage rate is 17%, for which costs of the ‘VPR’ and ‘No VPR’ scenarios are equivalent. At this break-even domestic coverage rate, refugees would receive an average of 6.9 doses under the ‘VPR’ scenario, compared to just 1.6 doses under the ‘No VPR’ scenario. For the domestic revaccination rates (Figure 3), the net cost savings per person varied from $225.93 with the base case of 0% domestic revaccination rates to −$46.17 with the rate of 100%. The break-even revaccination rate was 83%.

From PSA, the 99% credibility interval (CI) of net cost savings of the ‘VPR’ scenario compared to the ‘No VPR’ scenario ranges from $221.4 to $301.4 (Table 1). The results of PSA also confirm the robustness of net savings with the VPR.

4. Discussion

The net cost savings due to the VPR are $225.93 (29%) per person, assuming that a refugee complete all ACIP-recommended vaccination schedules. When we limited the analysis to vaccines included in VPR, the ‘VPR’ scenario is 56% less costly than the ‘No VPR’ scenario. The results are consistent with a previous analysis of pre-departure vaccination for US-bound refugees, which estimated $235 net cost savings per-refugee in 2005 US dollars ($285 per refugee in 2015 US dollars) for vaccines included in VPR [13].

The total amount of annual net cost savings associated with VPR depends on numbers of refugee arrivals per year, coverage rates of VPR, distribution of departed locations, and the net cost saving per person. Based on results from our analyses, the base case estimates of annual cost savings under the ‘VPR’ scenario compared to ‘No VPR’ scenario are $15.8

million, assuming an average of 70,000 refugee arrivals per year [1]. The estimated annual cost savings are ranged from $11.3 million assuming 50,000 arrivals to $24.9 million assuming 110,000 arrivals.

Since the number of refugees and distribution of countries from which refugees depart varies year-to-year, the potential cost savings from the VPR will vary. VPR comprised about 72% of total refugee arrivals in FY 2016. The extension of VPR to 100% coverage of US-bound refugees would increase annual net cost savings. However, depending on the distribution of US-bound refugees in any given year, it could also decrease average net cost savings per person because of higher operational, and logistics costs in some countries, which are not currently covered by VPR. The expansion of VPR to additional countries requires time to recruit and train staff, to ensure adequate power supplies for vaccine cold chains, and possibly to obtain permission to import certain vaccines in selected countries.

The base case estimates are based on a conservative assumption that RMA or Medicaid cover all vaccination costs for refugees. When we use the estimated private sector payments for domestic costs, the upper-bound annual cost savings are $34.9 million with 70,000 refugee arrivals per year ($498.42 per-refugee, Appendix Table A16). The upper-bound estimate is a plausible estimate when state or federal funding may not cover the domestic vaccination costs of refugees.

VPR is also expected to reduce costs as compared to delivering all vaccines post-arrival, even if 1) the domestic vaccination coverage rate is low or 2) the domestic revaccination rate is high. The results from the break-even analyses showed that the ‘VPR’ scenario could reduce costs as long as the domestic vaccination coverage rate is greater than 17%. The domestic vaccination coverage rates lower than 17% are not realistic because of federal, state, and local vaccination requirements. Most refugees present for recommended post-arrival medical examinations, which provide at least one opportunity for refugees to receive vaccines. Most children have to demonstrate that they have received the ACIP-recommended vaccines to satisfy state and local requirements for daycare and school entry, unless they are exempted because of medical, religious, or other reasons [4, 14]. Although adults may not have these requirements, at least one dose of each ACIP-recommended vaccine is required to adjust their immigration status to become a legal permanent resident [15]. Refugees can begin applying for a permanent residence 1 year after arriving in the United States [4].

Furthermore, even if cost savings are less than expected due to low domestic coverage rates, refugees would still receive more doses of vaccines under the ‘VPR’ scenario. For example, the average number of VPR vaccine doses per person is 9.3 doses to fulfill the ACIP-recommended schedule for these VPR vaccines, while an average of 6.4 doses per person (67% completion) are given under the ‘VPR’ scenario prior to departure. At the break-even domestic coverage rate (17%), refugees would have received a total of 6.9 doses under the ‘VPR’ scenario (6.4 overseas doses and 0.5 domestic doses), compared to just 1.6 doses under the ‘No VPR’ scenario.

For coverage rates greater than 17%, the ‘VPR’ scenario is both less expensive and achieves better health outcomes, because refugees would almost always receive more vaccine doses

under the ‘VPR’ scenario compared to the ‘No VPR’ scenario. The reduced risk of infection with VPDs under the ‘VPR’ scenario is especially important, since refugees are less likely to be protected from these diseases prior to departure than after arrival in the United States [2, 4, 16, 17]. Thus, VPR should reduce the possibility that refugees could arrive in the United States with a VPD, initiating a VPD outbreak in their new US communities. These potential health benefits are not considered in our analyses, as discussed in the limitations below.

The second break-even analysis considers the potential for domestic revaccination to reduce the cost savings from the VPR. The revaccination rates higher than 83% would result in extra costs for the VPR. Another minor concern associated with revaccination is that over-vaccination with some vaccines may increase the risk of adverse events. Revaccination might occur if domestic health departments do not use vaccination records from the VPR to determine how many doses of vaccines are required to fulfill the ACIP-recommended schedule after resettlement, either due to missing documentation or because healthcare workers decide that overseas doses are not valid. However, revaccination rates among refugees in the United States are expected to be much lower than the break-even revaccination rates identified in our analyses. For instance, the domestic MMR revaccination rates among newly arrived refugees were less than 11% during 2013–2015 [18].

Overall, VPR reduces the costs of refugee vaccination across a range of parameter assumptions and uncertainty analyses. Potential cost savings are divided across the federal VFC, federal RMA, and federal/state Medicaid programs. Although our evaluation includes the federal, states, and local governments’ payments, federal funding currently covers most vaccination costs for refugees. It is possible that the funds could be used for other public health programs to improve refugee health after resettlement.

Another strength of this evaluation is that we considered cost savings associated with adult vaccination among refugees. Adult vaccination in the United States does not get much attention compared to childhood vaccination [19]. However, adult vaccination is a serious concern for refugees who may not have been vaccinated as children. The estimates from this study showed substantial cost savings among adult refugees under the ‘VPR’ scenario, compared to the ‘No VPR’ scenario. Also, this evaluation used the actual program budget data to calculate overseas vaccination costs for refugees. The sensitivity analyses with overseas input parameters provide a reasonable range of estimates by using inputs from different countries. A retrospective evaluation of pre-departure vaccination costs for refugees using actual data has never been published elsewhere.

Other countries with refugee resettlement programs may also consider pre-departure vaccination programs. The pre-departure vaccination costs reported in this analysis could be used by those countries. Resettlement countries with similar domestic vaccination costs as the United States would also likely achieve net cost savings by vaccinating refugees before departure.

This evaluation has some limitations. First, we do not include potential cost savings resulting from any reductions in numbers of VPD cases and their sequelae. Prior to VPR, detection of measles and polio cases among US-bound refugees incurred costs to the federal government,

because refugee resettlement had to be postponed until outbreak control activities were implemented [2, 16]. The treatment and response costs of refugee-associated measles events in the United States were about $27,000 for a single case in 2010, and about $145,000 for an outbreak with seven cases in 2011 (2015 US dollars)[2, 4]. With VPR in place, it would not be necessary to postpone resettlement activities due to VPD cases, because US-bound refugees would be sufficiently protected due to vaccination. We expect that VPR could save additional outbreak response costs, and these additional savings would be significant.

Next, we assumed that domestic vaccine administration fees cover all costs for vaccination except vaccine costs. If the fees account for only some of staff and overhead costs for vaccination, net cost savings may be underestimated. Also, the overseas program costs included costs for HepB testing and documentation of valid overseas historical vaccinations. Our analyses, however, do not account for the potential health benefits of early diagnosis of HepB or for a reduction in domestic or overseas vaccination costs due to the documentation of historical (pre-VPR) vaccine doses. Thus, we may overestimate the overseas costs and underestimate the potential cost savings of VPR.

This analysis is not applicable to US asylees. Asylees, unlike refugees, seek legal status at US ports of entry or at land border crossings, and cannot be targeted for vaccination before arriving in the United States.

5. Conclusions

Our findings confirm that VPR significantly reduces vaccination costs for US-bound refugees, as compared to vaccination after arrival in the United States. Our estimates showed that net cost savings under VPR are about $225.93 per person with RMA or Medicaid payments for domestic costs. The expansion of VPR to include additional countries or additional vaccines would probably increase the US government’s cost savings.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Highlights

- Vaccination Program for US-bound Refugees (VPR) provides selected vaccines overseas.
- VPR reduces vaccination costs for refugees across all age groups.
- Net savings per person vary from $226 (Medicaid rates for domestic costs) to $498 (private sector).
- Annual cost savings with VPR are $15.8–34.9 million (Medicaid-private sector) for 70K refugees.
- VPR reduces risks of refugees with potential for vaccine-preventable diseases outbreaks in the US.

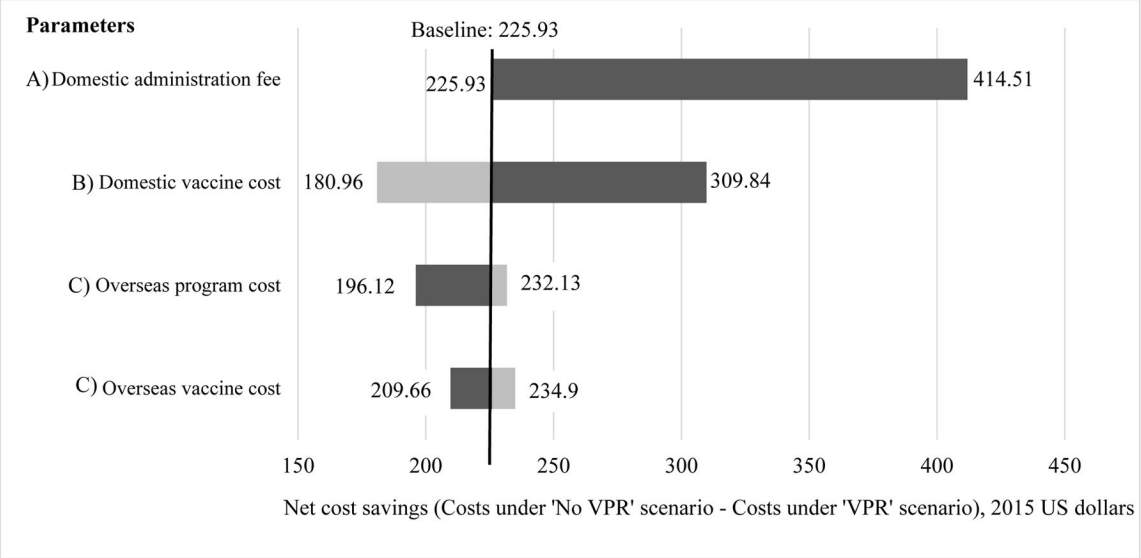

Figure 1.

One-way sensitivity analyses for net cost savings per person by comparing costs under 'VPR' scenario to costs under 'No VPR' scenario (2015 US dollars). The width of horizontal bars shows the change in net cost savings when each parameter was varied over the ranges as follows: A) domestic administration fee varies from the lower-bound of Medicaid reimbursement rates, which are as same as the baseline, to the upper-bound of private sector payments (Appendix Table A10); B) domestic vaccine cost varies from CDC vaccine purchasing price for non-insured or under-insured adults and Medicaid reimbursement rates for children (lower-bound, Appendix Tables A6–A7) to private sector payments (upper-bound, Appendix Tables A6–A7); and C) overseas program cost and vaccine cost vary from the lower-bound of the first quartile of country-specific costs from the VPR-implementing countries to the upper-bound of the third quartile of the country-specific costs (Appendix Table A11).

Note: VPR, Vaccination Program for US-bound Refugees. When both domestic administration fee and vaccine costs vary from the lower-bound to the upper-bound, the net cost savings per person changed from $180.96 to $498.42. The upper-bound of net cost savings ($498.42) are based on private sector payments.

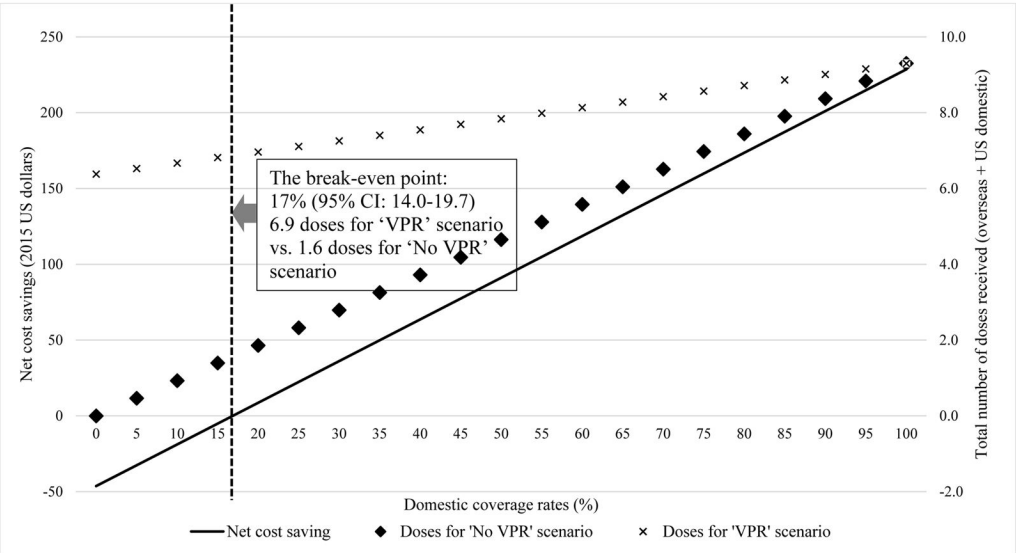

Figure 2.

Average net cost savings per person and average numbers of doses received per person for the 'VPR' and 'No VPR' scenarios by domestic coverage rates

Notes: DTaP, diphtheria, tetanus, and acellular pertussis; DTP, diphtheria, tetanus, and pertussis; Tdap, tetanus, diphtheria, and acellular pertussis; Td, tetanus, diphtheria; HepB, hepatitis B; Hib, *Haemophilus influenzae* type b; IPV, inactivated poliovirus; OPV, oral polio virus; MMR, measles, mumps, and rubella; VPR, Vaccination Program for US-bound Refugees. The analyses only included five vaccines, DTaP/DTP/Tdap/Td, HepB, Hib, IPV/OPV, and MMR, which are provided through VPR. Baseline is 100% of the domestic coverage rate. The domestic coverage rate does not affect net cost savings for vaccines not included in VPR (e.g., varicella). The break-even points, indicated with the vertical dashed-line, represent the domestic vaccine coverage rate for which the costs to US governments for the 'VPR and 'No VPR' scenarios are equivalent. At the break-even coverage rate of 17.0%, refugee vaccination costs for the five VPR vaccines are $69 per person under both the 'VPR' and 'No VPR' scenarios. However, the refugees would receive an average of 6.9 doses under the 'VPR' scenario compared to just 1.6 doses under the 'No VPR' scenario.

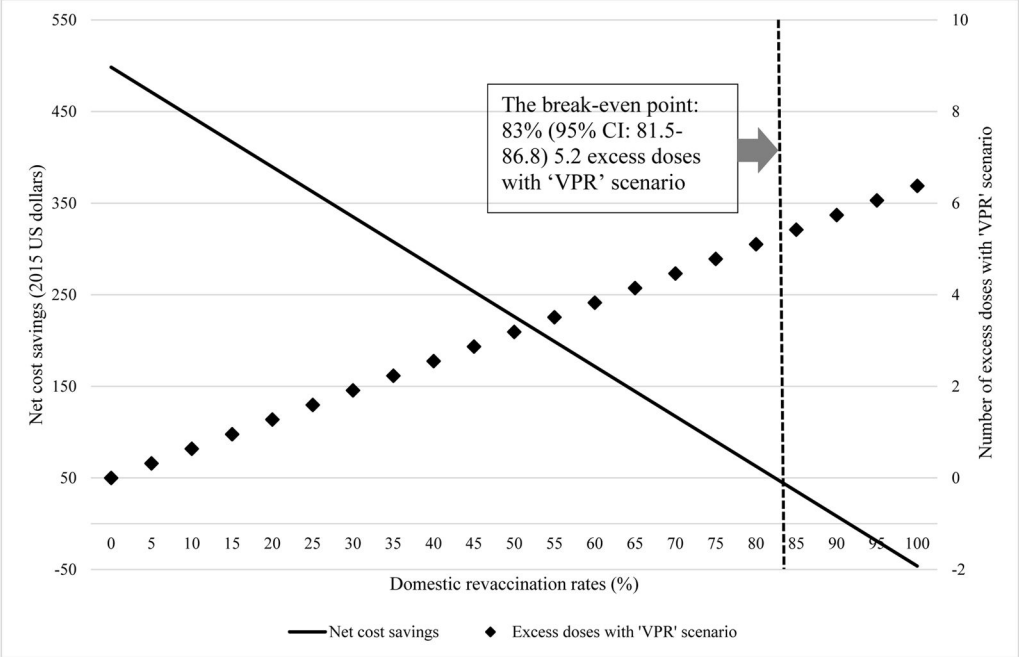

Figure 3.

Average net cost savings per person ('VPR' vs. 'No VPR') by domestic revaccination rates Notes: DTaP, diphtheria, tetanus, and acellular pertussis; DTP, diphtheria, tetanus, and pertussis; Tdap, tetanus, diphtheria, and acellular pertussis; Td, tetanus, diphtheria; HepB, hepatitis B; Hib, *Haemophilus influenzae* type b; IPV, inactivated poliovirus; OPV, oral polio virus; MMR, measles, mumps, and rubella; VPR, Vaccination Program for US-bound Refugees. The analyses only included five vaccines, DTaP/DTP/Tdap/Td, HepB, Hib, IPV/OPV, and MMR, which are provided through VPR. Baseline is the 0% revaccination. The domestic coverage rate does not affect net cost savings for vaccines not included in VPR (e.g., varicella). The break-even revaccination rate, indicated with the vertical dashed-line, represents the rate the cost of the 'VPR' scenario is equal to the 'No VPR' scenario. At the break-even revaccination rate of 83%, the cost estimates for both the 'VPR' and 'No VPR' scenarios are $407 per person.

Table 1

Costs of full vaccination per person, except for influenza, with and without the Vaccination Program for US-bound Refugees (VPR), by age group (2015 US dollars)

All vaccines except influenza vaccines

	Age distribution	'No VPR' scenario (a)	'VPR' scenario			Net cost savings (a)–(b)	Percent cost reduction $\frac{(a)-(b)}{(a)}$ (%)
			Total (b)=(c)+(d)	Domestic (c)[2]	Overseas (d)		
Infant to 4.9 years old	9%	725.37	522.56	469.70	52.86	202.81 (184.7–423.0)	28.0% (25.7–36.4)
5–10.9 years old	12%	653.31	454.68	400.23	54.45	198.63 (184.6–407.1)	30.4% (28.3–40.2)
11–18.9 years old	15%	1,296.11	1,134.58	1,090.43	44.15	161.53 (144.7–355.5)	12.5% (11.1–21.3)
≥19 years old	64%	698.64	449.25	405.10	44.15	249.39 (198.9–334.7)	35.7% (29.7–42.3)
Overall[1]	100%	785.23	559.30	513.13	46.17	225.93 (221.4–301.4)	28.8% (27.3–33.0)

Vaccines provided by the VPR only (DTaP/DTP/Tdap/Td, HepB, Hib, IPV/OPV, and MMR)

	Age distribution	'No VPR' scenario (a)	'VPR' scenario			Net cost savings (a) – (b)	Percent cost reduction $\frac{(a)-(b)}{(a)}$ (%)
			Total (b)=(c)+(d)	Domestic (c)[2]	Overseas (d)		
Infant to 4.9 years old	9%	416.27	213.46	160.60	52.86	202.81 (184.7–423.0)	48.7% (44.6–55.5)
5–10.9 years old	12%	379.51	180.88	126.43	54.45	198.63 (184.6–407.1)	52.3% (48.4–59.6)
11–18.9 years old	15%	375.12	213.59	169.44	44.15	161.53 (144.7–355.5)	43.1% (38.9–54.4)
≥19 years old	64%	417.79	168.40	124.25	44.15	249.39 (198.9–334.7)	59.7% (53.8–65.1)
Overall[1]	100%	406.66	180.73	134.56	46.17	225.93 (221.4–301.4)	55.6% (52.3–59.8)

Notes: DTaP, diphtheria, tetanus, and acellular pertussis; DTP, diphtheria, tetanus, and pertussis; Tdap, tetanus, diphtheria, and acellular pertussis; Td, tetanus, diphtheria; HepB, hepatitis B; Hib, *Haemophilus influenzae* type b; IPV, inactivated poliovirus; OPV, oral polio virus; MMR, measles, mumps, and rubella.

Results of probabilistic sensitivity analyses, 99% credible range, were shown in parentheses.

[1] Numbers shown in the overall row are the weighted average of costs or savings for each age group using the percentage weight of each age group.

[2] Since the VPR provides 1 or 2 doses of selected vaccines shown in the bottom part of Table 1, domestic costs with the VPR includes the costs to complete remaining doses of vaccines, which were not provided by the VPR.

Table 2

Overall costs of vaccination per person with and without the Vaccination Program for US-bound Refugees by type of cost (2015 US dollars)

	'No VPR' scenario (a)	'VPR' scenario			Net cost savings (a) – (b)
		Total (b)=(c)+(d)	Domestic (c)	Overseas (d)	
Vaccine costs					
VPR vaccines (e)[1]	275.43	97.96	84.43	13.54	177.47
Non-VPR vaccines (f)	326.02	326.02	326.02	N/A	0
Total vaccine costs (g)=(e)+(f)	601.45	528.26	514.72	13.54	177.47
Administration costs (h)	183.77	135.32	102.68	32.63	48.45
Total vaccination costs (g)+(h)	785.23	559.30	513.13	46.17	225.93

Notes: All numbers in Table 2 are the age-weighted average costs or savings.

[1]VPR vaccines include DTaP/DTP/Tdap/Td, HepB, Hib, IPV/OPV, and MMR.