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Vaccine delivery to newly arrived refugees and estimated costs in selected U.S. clinics, 2015

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Abstract

Background: Newly arrived refugees are offered vaccinations during domestic medical examinations. Vaccination practices and costs for refugees have not been described with recent implementation of the overseas Vaccination Program for U.S.-bound Refugees (VPR). We describe refugee vaccination during the domestic medical examination and the estimated vaccination costs from the US government perspective in selected U.S. clinics.

Methods: Site-specific vaccination processes and costs were collected from 16 clinics by refugee health partners in three states and one private academic institution. Vaccination costs were estimated from the U.S. Vaccines for Children Program and Medicaid reimbursement rates during fiscal year 2015.

Results: All clinics reviewed overseas vaccination records before vaccinating, but all records were not transferred into state immunization systems. Average vaccination costs per refugee varied

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Authors' contributions

CP, AM, HJ, BM, and DL conceived the design of the assessment, acquired and interpreted data, and drafted the manuscript. JC, LS, EF, BM, KU, SH, CP, and KS acquired data and revised manuscript for important intellectual content. All authors approved the final draft of the manuscript.

Ethical approval

This assessment was determined non-research by National Center for Emerging and Zoonotic Infectious Diseases Human Subjects Advisor and the Massachusetts Department of Public Health Institutional Review Board.

Disclaimer

The findings and conclusions in this report are those of the authors and do not necessarily represent the official position of CDC.

Appendix A. Supplementary material

Supplementary data associated with this article can be found, in the online version, at https://doi.org/10.1016/j.vaccine.2017.12.023

Conflict of interest

All authors have no conflicts of interest.

from $120 to $211 by site. The total average cost of domestic vaccination was 15% less among refugees arriving from VPR-vs. nonVPR-participating countries during a single domestic visit.

Conclusion: Our findings indicate that immunization practices and costs vary between clinics, and that clinics adapted their vaccination practices to accommodate VPR doses, yielding potential cost savings.

Keywords

Refugee health; Refugee immunizations; Vaccine preventable diseases; Vaccine costs; Cost-benefit

1. Introduction

The United States has accepted approximately 70,000 refugees annually for resettlement in recent years [1]. Although immigrants are required to have documented Advisory Committee on Immunization Practices (ACIP)-recommended [2] vaccines prior to U.S. entry ((8 U.S.C. 1182)(a)(1)(A)(ii)), refugees are not subject to this requirement.

During 2012, the U.S. Centers for Disease Control and Prevention (CDC) and the Bureau of Population, Refugees, and Migration (PRM) of the Department of State (DOS) developed the overseas Vaccination Program for U.S.-bound Refugees (VPR). The objective of VPR is to prevent morbidity, mortality, and costly travel delays associated with vaccine-preventable disease (VPD) outbreaks during the resettlement process and to facilitate earlier school enrollment for children after arrival [3–6]. The program was implemented by the International Organization for Migration (IOM). At the time of this analysis, U.S.-bound refugees examined in the participating countries of Ethiopia, Kenya, Malaysia, Nepal, Thailand, and Uganda were offered up to two doses of five ACIP- recommended vaccines (hepatitis B [HepB]; inactivated poliovirus [IPV]; diphtheria/tetanus/pertussis-containing vaccines [DTP/DTaP/DT/Td/Tdap]; measles, mumps and rubella combination vaccine [MMR]; and *Haemophilus influenzae* type B [Hib]) in the 3–6 month interval between overseas medical examination and departure for the United States [3]; the program has since expanded to new vaccines (Pneumococcal Conjugate [PCV13] and Rotavirus), and to 21 countries [7,8]. The program is jointly funded by the U. S. Department of Health and Human Services/CDC and DOS/PRM. More information on VPR is available elsewhere [8].

CDC recommends that refugees be referred for a federally funded medical examination at a local health department or healthcare provider within 90 days [9] upon arrival in the United States. The examination's purpose is to follow-up on health conditions noted overseas and link refugees to the U.S. healthcare system. CDC domestic screening guidelines recommend that clinicians take this opportunity to provide the appropriate ACIP- recommended vaccines to refugees [9].

Vaccination activities during the domestic medical examination are not well documented in the literature, and we know little about the domestic vaccination costs. Here, we report on how refugees' medical records are evaluated for documentation of receipt of prior vaccinations, describe the decision-making process that guides domestic vaccination, as well as the extent to which overseas and domestic vaccine doses are documented in state

immunization information systems (IIS) during the domestic medical examination [10]. Although previous publications describe site-specific vaccination processes and costs [11,12], we analyzed vaccination practices in sixteen clinics in three states and one institution during the domestic medical examination, and estimated vaccination-specific costs from the U.S. government perspective.

2. Methods

2.1. Participants

We collaborated with four partners (referred to as 'sites' in this paper): three states, and one university medical system. The three states provided data from five clinics each (15 total), all of which participate in federally funded domestic refugee screening programs, such that the selected clinics screen at least 70% of each state's annual refugee arrivals. The university medical system provided data from one clinic that screens 10% of annual refugee arrivals to the state in which it is located. The four sites provided information on any recently arrived refugees who received a domestic medical examination in one of the 16 participating clinics during three 2-week time periods in July 2014, November 2014, and March 2015. Each refugee was counted as a single observation regardless of the number of clinic visits during the three time periods. The sites also collected aggregated information on the number and type of vaccines given to refugees as part of the domestic medical examination during the three time periods. We categorized persons <19 years old as children and persons ≥19 as adults, per ACIP definition [2].

2.2. Data collection

Site partners extracted aggregated refugee data, stratified by age and country of overseas exam from their refugee health surveillance systems, and clinics summarized their immunization practices and unit charges for services.

2.3. Measures

2.3.1. Clinic immunization practices—Sites provided information on the types of participating clinics conducting domestic medical examinations (e.g., health departments, community health clinics, etc.) in their jurisdictions, as well as immunization/titer screening protocols used by clinics. Clinics provided information on refugee screening and immunization practices for 10 specific vaccines: HepB, IPV, DTP/DTaP/DT/Td/ Tdap, MMR, Hib (VPR vaccines) and human papillomavirus (HPV), hepatitis A (HepA), meningococcal, pneumococcal, and varicella vaccines (nonVPR vaccines). In addition, clinics reported the proportion of the screening medical exam devoted to vaccination, and their access to, and use of, overseas immunization information and domestic antibody testing results to determine vaccination needs. Clinics also reported the extent to which domestic vaccination data were recorded in electronic health records, refugee health surveillance systems, and state IIS.

2.3.2. Cost indicators—Sites collected information from clinics on billing practices for the domestic medical examination, including proportion of total visit time spent on vaccination, Current Procedural Terminology (CPT) codes used to bill for refugee clinic

visits, vaccine costs, vaccine administration fees, refugee health examination visit costs, number of office visits associated with the examination, antibody testing for immunity, and reporting of overseas and domestic vaccines to state IIS. All clinics received children's vaccines through the Vaccines for Children (VFC) program, a federal program providing vaccines at no cost to children not otherwise able to pay, or an alternative source [13], and two of the four clinics were able to provide price data for adult vaccines. Clinics also reported information on the type and number of vaccine doses given during the exams, aggregated by refugees' age and country of origin. Individual-level billing data were not available and billed amounts may depend on the insurance status of individual patients. Refugees have coverage primarily through Medicaid jointly administered by the U.S. federal and State governments or the Refugee Medical Assistance program administered by the federal Office of Refugee Resettlement. In place of billing data, we estimated average charged amounts per refugee based on data provided by sites and estimates of vaccine prices as summarized below.

2.4. Analyses

2.4.1. Clinic immunization practices—To summarize clinic immunization practices, we tabulated clinic-reported access to overseas immunization records by site, clinic use of antibody testing by vaccine (HepB, varicella, HepA, and MMR) by site, clinic documentation of overseas vaccine doses, and reporting of domestic vaccine doses administered by site and age group (child or adult).

2.4.2. Cost analysis—Analysis was conducted on costs associated with vaccines administered during the domestic medical examination using U. S. CDC *Vaccine Price List* (archived January 5, 2015) and Medicaid reimbursement rates. All costs were estimated using 2015 dollars from the US government perspective (costs to federal, state, and local governments). We calculated the average number of doses given and the average cost to vaccinate per refugee during the post-arrival exam by site and age; more detailed information on our methods is in the Appendix. We determined the average number and cost of vaccines given to refugees stratified by whether or not they were examined in a country participating in VPR at the time of their overseas medical evaluation. We made the following assumptions to calculate the average vaccination costs per refugee by site:

(1) Clinic-provided data on vaccine charges approximated actual cost to the federal government.

(2) For children's vaccine unit costs at clinics supported by VFC, we used costs published in the CDC *Vaccine Price List* archived January 5, 2015 [14]. When there were multiple manufacturers or formulations for a given vaccine, we used a weighted average to estimate costs as recommended (personal communication Fangjun Zhou, CDC Immunization Services Division, July 15, 2016).

(3) Adult vaccine prices were not provided by two sites. In the absence of specific data, we assumed the cost to clinics for adult vaccines was the midpoint of the adult CDC price and adult private sector prices reported on CDC *Vaccine Price List* archived January 5, 2015.

(4) We added 5% to the listed vaccine prices to account for wastage, which may occur from accidental damage or expiration of unused doses.

(5) Clinics generally reported a two-visit model (i.e., initial + follow-up) for the domestic medical examination, with different charges corresponding to each visit. Vaccination activities could take place during either visit, so we averaged the charges of the two visits and applied that estimate to all unique refugees included in the sample.

(6) We requested the sites estimate the average proportion of the domestic medical examination charge was associated with vaccines to account for overhead and staff time spent reviewing immunization records; ordering, storing, and preparing vaccine; and counseling refugees. We calculated vaccine-associated examination costs based on this proportion (clinic-provided estimates).

(7) For clinics reporting different initial and subsequent vaccine administration fees, we averaged the two fees to estimate administration fee per dose.

Using these assumptions, we calculated the total vaccine costs by summing variable and fixed costs. Variable costs, or costs dependent on the number of vaccine doses provided, included vaccine product cost and administration fee. Fixed costs, or costs independent of the number of vaccine doses provided, included the visit cost associated with vaccination.

The average cost per refugee screened in each site was then calculated from:

$$\frac{\sum_{i=1}^{10}(Number\ of\ doses_i \times (Product\ cost_i + Adminstration\ fee)) + (Visit\ \text{cost}\ associated\ with\ vaccination\ \times\ \#\ Refugees\ screened)}{\#\ Refugees\ screened}$$

In the formula, i represents the 10 different vaccines evaluated. Each vaccine had a specific product cost, but the same administration fee as provided by sites. The site-specific variable costs were calculated by multiplying the number of vaccine doses by the sum of the product cost and administration fees. Site-specific fixed costs were calculated by multiplying the visit costs associated with vaccination in the screening examination by number of refugees screened. The total vaccination cost was the sum of the variable cost and the fixed cost; the total vaccination cost was divided by number of refugees examined per site to calculate average cost per refugee.

2.4.3. Sensitivity analysis—We performed a sensitivity analysis to calculate alternative cost estimates; numbers and types of vaccines were held constant by site, while unit cost estimates varied. The lower-bound scenario used CDC vaccine purchasing prices from the CDC *Vaccine Price List* archived January 5, 2015, and assumed no wastage (detailed data available in the Appendix). [15,16] For vaccine administration fees, the lower-bound vaccine administration costs were based on national average Medicaid reimbursement rates, which were estimated from allowable Medicare rates and state average ratios comparing Medicaid versus Medicare reimbursement rates. [17,18] The Medicaid estimate was weighted to account for the distribution of refugee arrivals by state. The lower-bound estimate assumed that 10% of the comprehensive exam fee would apply to vaccination at each site. The upper-bound scenario used private sector vaccine prices from the CDC

Vaccine Price List archived January 5, 2015 (adjusted for 5% wastage) and private sector vaccine administration fees from the Physicians' Fee and Coding Guide. [16]The upper-bound estimate assumed that 40% of the exam fee was dedicated to vaccination. Our sensitivity analysis included administration fees for both lower and upper bounds, even though two of our sites reported not charging administration fees for vaccines (i.e. $0 charge).

All analyses were performed using Microsoft Excel (2013), Stata version 13 (StataCorp: College Station, TX), and SAS 9.4 (SAS Institute: Cary, NC).

3. Results

We received data from 16 clinics representing the initial domestic medical examinations of 926 (10.9%) of 8467 newly arrived refugees to the four sites in our three sampled 2-week periods during 2014 (Table 1). The 16 clinics included five community health centers, four non-profit organizations, two health departments, three university-affiliated institutions and two for-profit organizations. Overall, 60.7% of the refugee arrivals in this analysis were screened overseas in 6 VPR-participating countries; the proportion of arrivals from VPR-participating countries ranged between 45% and 80% by site. The proportion of arrivals by VPR- participating country and age was similar between our sample and overall arrivals to the four sites during the same time period. The average number of days between refugee arrival and initial screening exam was 30 days (range: 8–65).

3.1. Clinic immunization practices

Clinics reported accessing overseas vaccination records through CDC's Electronic Disease Notification (EDN) system, an electronic database that securely transmits overseas medical screening information to U.S. health departments and clinics, or from hard copy records from state health departments, resettlement agencies, or refugees themselves, hand-carried during travel (Table 2). [19] Clinics most commonly reported receiving hard copy records from refugees; less than half used EDN to access overseas records. However, all clinics reported having access to overseas immunization records. Antibody testing for evidence of immunity to VPDs was performed in all 16 clinics, although ages of refugees tested, purpose of testing, and specific serologic tests differed depending on whether the clinics used results for determining patient immune status or for other diagnostic purposes. Clinics also varied in how they documented and reported both overseas and domestic doses of vaccines (Table 2); some did not report these vaccine doses to state IIS.

3.2. Cost analysis

The 16 screening clinics reported administering 2167 doses of vaccine to newly arrived refugees during the time period for this analysis (Table 3). The average number of doses administered per refugee ranged between 1 and 4 by site (Table 3). Refugees examined in VPR-participating countries received fewer doses of VPR-provided vaccines after arrival relative to refugees traveling from countries without VPR (Table 4). The differences in doses of HepB, IPV, tetanus-containing, and MMR vaccines received for those examined in VPR vs. non-VPR country were significant ($p < .01$), but not significant for doses of Hib. No

significant differences between having an exam in VPR country vs. a non-VPR country were observed for receipt of vaccines not given through VPR (HPV, meningococcal, pneumococcal, HepA and varicella).

The average vaccination costs per refugee varied from $120 to $211 by site (Table 5). Vaccination costs were subdivided into three categories: (1) percentage of domestic medical examination time, (2) vaccine product and administration costs for VPR-provided vaccines, and (3) vaccine product and administration costs for nonVPR-provided vaccines. Stratifying costs into these categories (Table 6), the average cost of domestic vaccines included in the VPR program given per refugee was 51% less for refugees from VPR vs nonVPR-participating countries ($33.76 vs. $68.80). Average vaccination costs for vaccines not included in the VPR program were 12% higher ($63.29 vs. $56.71) for refugees arriving from VPR-participating countries. The domestic medical examination costs were estimated independently of the numbers and types of vaccine given, and were roughly equal ($46.51 vs. $43.94). Overall, the total average cost of domestic vaccination was 15% less among refugees from VPR vs nonVPR-participating countries.

3.3. Sensitivity analysis

In our sensitivity analysis (Table 5), the cost estimates based on reported charges for the two sites that did not charge for vaccine administration were 2–8% lower than the lower-bound estimates based on allowable Medicaid reimbursement rates. The upper-bound estimates based on private insurance reimbursement rates were approximately 2–3 times greater than the lower-bound, and all cost estimates based on reported charges were less than the upper-bound estimate.

4. Discussion

This analysis provides insight into domestic approaches to refugee vaccination and federal government costs incurred during the domestic medical examination. It demonstrates that clinics are adjusting their vaccination practices to account for vaccines received overseas through the VPR. When making decisions about which vaccines are still needed, clinics account for overseas vaccination during the domestic medical examination. The analysis also revealed differences in immunization practices and costs among the four sites.

Our analysis indicates that domestic refugee immunization practices varied widely between sites and clinics during the domestic medical examination. Refugee arrivals also had different immunization needs based on origin country, which have been impacted by the VPR implementation overseas.

Information in EDN and the documents in the IOM bag carried by the refugee are the most up-to-date source of overseas vaccination records for refugees. Not reviewing these records could result in incomplete documentation of pre-departure vaccination and unnecessary re-vaccination in the United States, particularly as the VPR expands. While only 38% of clinics reported having direct EDN access, state refugee health programs reported providing these clinics with copies of overseas vaccination records from EDN, so most clinicians should have access to overseas immunization information even if a refugee loses the physical copy

of his or her records. Domestically, some clinics indicated they do not report all of a refugee's vaccinations to the state immunization systems, which could result in re-vaccination if refugees seek care elsewhere.

Vaccination costs also differed by site. The average cost of immunization per refugee ranged from an estimated $120 to $211, which reflects the site-specific differences in the numbers of vaccines given and the charges per dose. We found that fewer doses of VPR vaccines were given domestically to refugees arriving from VPR-participating countries compared to refugees arriving from nonVPR-participating countries. The age and overseas origin of refugee populations screened in clinics, clinic type (i.e., a screening-only clinic or a refugee's medical home), and state or local guidelines on immunization are other potential factors affecting vaccination practices and costs by site.

Compared to a published cost estimate of refugee vaccine administration costs in Georgia ($14.50 in 2015 U.S. dollars after adjustment using the medical care consumer price index), administration charges in our analysis were approximately equivalent in one site ($15.00), higher in one ($37.50), and lower in two (for sites where vaccine administration costs are included in visit fees) [11]. A study of administration costs among different provider types found that, after adjusting 2004 costs to 2015 U.S. dollars, total administration costs to providers ranged from $15.22 per vaccine dose at pediatric practices to $7.79 at public health clinics [12]. Two sites in our analysis did not charge separate administration fees, and we were not able to measure how/if visit fees may change if the future if fewer vaccines are delivered at the examination. In 3 of 4 sites, cost estimates based on clinic charges were very close or slightly less than estimates based on allowable Medicaid reimbursement rates. However, at one site, charges were comparable to estimates of private insurance reimbursement rates and more than double our estimate of Medicaid-allowable amounts.

Our analysis had limitations. First, the costs calculated were based on a series of assumptions and clinic-reported charges that may not reflect true costs to the U.S. government. This analysis was also limited in scope and did not account for all potential costs associated with vaccination (e.g., patient transportation and foreign language interpretation), nor did it describe all costs to the U.S. government for vaccinating refugees, including overseas costs, longitudinal expenses to complete vaccine series, or cost savings from averting illnesses. We were unable to collect individual- level information on overseas VPR doses received by refugees in our dataset, so we could not directly observe the effects of VPR on domestic vaccination practices. Most costs would be incurred by the federal government with the exception of state contributions for refugees enrolled in Medicaid at the time of their initial examination. Data collected for this analysis occurred shortly after the introduction of VPR overseas when clinics may have been less likely to review VPR documentation. Also, some vaccines are age-specific, which limited the sample size of newly arriving refugees and our ability to test for significant differences resulting from VPR. Finally, this analysis only reflects findings from 16 clinics and is not nationally representative.

Appropriate and timely vaccination is vital to protect both the health of new refugee arrivals to the United States and the health of the receiving communities. Our analysis indicates that

domestic programs have different approaches to implementing ACIP immunization recommendations for refugees, and that VPR influences decision about domestic refugee immunizations, potentially saving domestic vaccination costs for U.S. government. Also, as a result of VPR, refugees will be more likely to be at least partially vaccinated even if they do not present for their domestic medical examination because they will receive some immunizations overseas through the program. Continued expansion of VPR will likely result in further changes to domestic practices and government costs. Further assessments are necessary to better understand total costs associated with immunization of refugees.

5. Conclusions

Our evaluation describes the diverse vaccination practices by a select number of state refugee health programs during the initial domestic medical examination, and we provide an estimate for the domestic vaccination costs to vaccinate refugees during the examination. Our findings provide insight into the costs of administering vaccinations to newly arriving refugees in the United States as investments in overseas vaccination programs are expanding.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Abbreviations:

ACIP	Advisory Committee on Immunization Practices
CDC	Centers for Disease Control and Prevention
CPT	Current Procedural Terminology
DTP/DTaP/DT/Td/Tdap	diphtheria/tetanus/pertussis-containing vaccines
EDN	Electronic Disease Notification system
Hib	*Haemophilus influenzae* type B
HepA	hepatitis A
HepB	hepatitis B
HPV	human papillomavirus
IPV	inactivated poliovirus

IIS	immunization information systems
IOM	International Organization for Migration
MMR	measles, mumps and rubella combination vaccine
VPR	Vaccination Program for U.S.-bound Refugees
VPD	vaccine-preventable disease
VFC	Vaccines for Children program

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Table 1

Characteristics of refugee arrivals at four U.S. sites conducting domestic medical examinations by site–July 2014, November 2014 and March 2015.

Characteristics	Site 1	Site 2	Site 3	Site 4
U.S. refugee arrivals to jurisdiction, Fiscal Year 2014[1]	1941	2232	4082	212
Number and type of participating clinics[2]	4 CHC	3 NP	2 FP	1 Univ
	1 Univ	2 HD	1 CHC	
			1 NP	
			1 Univ	
Refugees screened[3]	278	368	240	40
% Screened from VPR-participating countries[4]	45%	80%	53%	53%
Average # Days between U.S. arrival and screening (Range)	30 (22–35)	25 (8–36)	36 (9–65)	26

[1] Fiscal Year 2014 is October 1, 2013 through September 30, 2014.

[2] CHC = Community Health Centers; Univ = University-affiliated clinic; NP = Non-profit clinic; HD = Health Department; FP = For-profit clinic.

[3] Sites provided information on unique recently arrived refugees who presented in participating clinics for the post-arrival screening exam during the three 2-week time periods in July 2014, November 2014, and March 2015.

[4] Vaccination Program for U.S. bound Refugees (VPR). Participating countries at the time of this assessment were Ethiopia, Kenya, Malaysia, Thailand, and Uganda.

Table 2

Domestic immunization screening and reporting practices for newly arrived refugees at four U.S. sites, by Site and Clinic–July 2014, November 2014 and March 2015 (N = 16).

Clinic immunization practices	Site 1 5 clinics	Site 2[2] 5 clinics	Site 3[2] 5 clinics	Site 4 1 clinic
Overseas immunization record source				
Direct access to EDN System[1]	5[1]	0	0	1
Hard copy from health department	0	3	0	0
Hard copy from refugee	5	3	2	0
Hard copy from resettlement agency	0	0	3	0
Antibody screening				
Hepatitis B	5[3]	4	5[5]	1
Varicella	5[3]	4[4]	2[5]	1[4]
Hepatitis A	0	3	0	1
Measles-mumps-rubella	0	1	2[5]	1[4]
Report of overseas and domestic vaccine doses into systems[6]				
State IIS	3	5[7]	4[7]	1[7]
RHS System	5	2	0	1[7]
EHR	5	5	3	1

[1] EDN is CDC's Electronic Disease Notification System. Site 1, the EDN information is available on this site's web-based disease surveillance and case management system.

[2] All clinics in these sites received immunization records by at least one method.

[3] Varicella is only tested in children over the age of 5 years, and adults. For Hepatitis B, 3 of these clinics vaccinate before test results are available.

[4] One clinic only tests children 13 years and older.

[5] One clinic only tests adults.

[6] Reporting of overseas and domestic vaccine doses for adults and children are presented. IIS is defined as immunization information system; RHS, Refugee Health Surveillance; EHR, Electronic Health Record.

[7] In Site 2, 4 of these clinics provide overseas and domestic vaccine doses for adults into the state IIS. In Site 3, 1 of these clinics provide overseas vaccine doses for adults into the state IIS, and 2 of these clinics provide domestic vaccine doses for adults into the state IIS. In Site 4, this clinic reports both overseas and domestic vaccine doses for adults into state IIS and the refugee health surveillance.

Table 3

Vaccines administered during domestic refugee screening examinations at 4 U.S. sites—July 2014, November 2014, and March 2015 (N = 926).

Vaccine	Site 1 5 clinics N = 278 n (%)	Site 2 5 clinics N = 368 n (%)	Site 3 5 clinics N = 240 n (%)	Site 4 1 clinic N = 40 n (%)	Total 16 clinics N = 926 n (%)
VPR[1]-provided vaccines					
Hepatitis B	134 (48)	50 (14)	92 (38)	9 (23)	285 (31)
Inactivated poliovirus	265 (95)	39 (11)	52 (22)	1(3)	357 (39)
Diphtheria/tetanus/pertussis-containing vaccines[2]	220 (79)	118(32)	196 (82)	16 (40)	550 (59)
Measles-mumps-rubella	219 (79)	44 (12)	92 (38)	2 (5)	357 (39)
Haemophilus influenzae type B	17 (6)	16(4)	7 (3)	-	40 (4)
Total VPR[1] vaccines	855	267	439	28	1589
NonVPR[1]-provided vaccines					
Human papillomavirus	88 (32)	27 (7)	1 (0)	4 (10)	120 (13)
Hepatitis A	16 (6)	17 (5)	8 (3)	-	41 (4)
Meningococcal	82 (30)	23 (6)	9 (4)	-	114 (12)
Pneumococcal	22 (8)	28 (8)	30 (13)	5 (13)	85 (9)
Varicella	61 (22)	45 (12)	109(45)	3 (8)	218 (24)
Total NonVPR[1] vaccines	269	140	157	12	578
Total vaccines administered	1124	407	596	40	2167
Average number of vaccines administered per refugee	4	1.1	2.5	1	2.3

[1]VPR is Vaccination Program for U.S. bound Refugees.

[2]The following diphtheria/tetanus/pertussis-containing vaccines were assessed: DT, DTaP, Td, and Tdap.

Table 4

Comparison of vaccination program for U.S.-bound refugees (VPR)- and nonVPR-provided vaccine doses administered to newly arrived refugees by VPR- and nonVPR-participating countries of examination in 16 clinics (N = 926).

Vaccines	Refugees from VPR-participating countries		Refugees from nonVPR-participating countries		*p*-value[1]
	N	%	n	%	
Total refugees screened	562	100.0	364	100.0	-
VPR[2]-provided doses administered					
Hepatitis B	130	23.1	155	42.6	<0.01[4]
Inactivated poliovirus	149	26.5	208	57.1	<0.01[5]
Diphtheria/tetanus/pertussis-containing vaccines[3]	273	48.6	277	76.1	<0.01[6]
Measles-mumps-rubella	112	19.9	245	67.3	<0.01[7]
Haemophilus influenzae type B	21	3.7	19	5.2	0.32
Average number of VPR[2]-provided vaccines per refugee	1.2		2.5		
NonVPR[2]-provided doses administered					
Human papillomavirus	75	13.3	45	12.4	0.69
Hepatitis A	29	5.2	12	3.3	0.19
Meningococcal	69	12.3	45	12.4	1.0
Pneumococcal	53	9.4	27	7.4	0.34
Varicella	133	23.7	85	23.4	0.94
Average number of nonVPR[2]-provided vaccines per refugee	0.6		0.6		
Total vaccines administered	1044		1138		-
Average number of vaccines administered per refugee	1.9		3.1		

[1] P-value is significant at $\alpha < 0.05$. The Fisher's exact test was used to calculate p-values for comparison of doses. Calculation does not account for potential clustering by state caused by site-specific vaccination policies and different resettlement populations.

[2] VPR is Vaccination Program for U.S. bound Refugees.

[3] The following diphtheria/tetanus/pertussis-containing vaccines were assessed: DT, DTaP, Td, and Tdap.

[4] Differences were significantly different in 1/4 sites.

[5] Differences were significantly different in 2/4 sites.

[6] Differences were significantly different in 1/4 sites.

[7] Differences were significantly different in 3/4 sites.

Table 5

Total vaccination costs for newly arrived refugees and average vaccination cost per refugee at 4 U.S. sites, by site with sensitivity analysis (n = 926).[1]

Charge type	Site 1 5clinics N = 278	Site 2 5 clinics N = 368	Site 3 5 clinics N = 240	Site 4 1 clinic N = 40
Variable costs[2]				
Vaccine products total (a)	$46,508	$18,850	$24,514	$4039
Administration charges				
Administration fee/dose (b)	0	$15	0	$38
Total number of vaccine doses (c)	1124	407	596	40
Administration charges total (d = b×c)	$0	$6284	0	$1500
Variable cost total (a + d)	$46,508	$25,134	$24,514	$5539
Fixed costs[3]				
Portion of examination charge related to vaccination per refugee (Fixed cost%)	$44 (25%)	$51 (36%)	$36 (35%)	$63 (25%)
Fixed cost total	$12,093	$18,878	$8664	$2500
Total vaccination cost	$58,601	$44,012	$33,178	$8039
Average vaccination cost per refugee	$211	$120	$138	$201
Sensitivity analysis average vaccination cost per refugee				
Lower Bound[4]	$219	$78	$136	$83
Upper Bound[5]	$494	$183	$306	$217

[1] Values have been rounded to the nearest dollar. In practice, there were two billing models. Sites 2 and 4 used a fee for service model in which both vaccine administration and vaccine purchase prices were billed separately. In sites 1 and 3, vaccine administration was included in the visit fee, but vaccines purchases were billed separately for adults. Note that for site 3, a fixed fee per refugee included other services such as diagnostic testing that we removed from the visit fee. Adult vaccine purchase prices were unavailable for sites 2 and 3 because of contracts that prohibited disclosure of prices. Children's vaccines at all 4 sites were provided via the CDC's Vaccines for Children program, under which CDC purchases and provides vaccines to clinics who can then provide the vaccine doses free of charge to eligible children.

[2] Variable costs are those dependent on the number of each vaccine provided as summarized in Table 3. Unit costs per vaccine and total costs for each vaccine are summarized in an online Appendix.

[3] Fixed costs are those independent of the number of each vaccine provided and are calculated from the number of refugees (N) multiplied by the vaccination cost per refugee.

[4] Vaccine for Children prices, 0% wastage, Medicaid administration costs, and 10% of exam fee (refer to online Appendix for additional detail). Note that the lower bound cost estimate for Site 1 greater than the base case estimate. For site 1, vaccine administration was not charged separately and were supposed to be considered in the visit fee.

[5] Private sector vaccine prices and administration fees, 5% wastage, and 40% of exam fee (refer to online Appendix for additional detail).

Table 6

Average cost for vaccination of newly arrived refugees of Refugee from Vaccinaton Program of U.S.-bound Refugees (VPR) vs. nonVPR-participating countries.

Average cost per refugee	Refugees from VPR-participating countries (A)	Refugees from nonVPR-participating countries (B)	% Difference ((A – B)/B)
VPR-provided vaccines[1] product and administration costs	$33.76	$68.80	−51%
NonVPR-provided vaccines[2] product and administration costs	$63.29	$56.71	+12%
Portion of examination charge related to vaccination (% of total exam for vaccination)	$46.51	$43.94	+6%
Total average cost per refugee	$143.57	$169.46	−15%

[1]VPR is Vaccination Program for U.S. bound refugees. VPR-provided vaccines are hepatitis B, inactivated poliovirus, diphtheria/tetanus/pertussis-containing vaccines (DT, DTaP, Td, Tdap), measles-mumps-rubella, and *Haemophilus influenzae* type B.

[2]NonVPR-provided vaccines are human papillomavirus, hepatitis A, meningococcal, pneumococcal, and varicella.