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An immunization program for US-bound refugees: Development, challenges, and opportunities 2012–present

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Abstract

Background: US-bound refugees undergo required health assessments overseas to identify and treat communicable diseases of public health significance—such as pulmonary tuberculosis—before migration. Immunizations are not required, leaving refugees at risk for vaccine-preventable diseases. In response, the US Centers for Disease Control and Prevention and the US Department

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Authors' contributions

TM and AK contributed to study conception and design, statistical analysis, and data interpretation; MW and WD contributed to study conception and design and data interpretation; CP contributed to statistical analysis and data interpretation; and all authors were involved in drafting or critically revising the manuscript for intellectual content. All authors reviewed and approved the final manuscript and attest they meet the ICMJE criteria for authorship.

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Declaration of Competing Interest

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Appendix A. Supplementary material

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.vaccine.2020.10.047>.

of State developed and co-funded a global immunization program for US-bound refugees, implemented in 2012 in collaboration with the International Organization for Migration.

Methods: We describe the Vaccination Program for US-bound Refugees, including vaccination schedule development, program implementation and procedures, and responses to challenges. We estimate 2019 immunization coverage rates using the number of age-eligible refugees who received 1 dose of measles-containing vaccine during overseas health assessment, and calculated hepatitis B infection prevalence using hepatitis B surface antigen testing results. We report descriptive data on adverse events following immunization.

Results: By September 2019, the program was active in >80 countries on five continents. Nearly 320,000 examined refugees had 1 documented vaccine doses since program inception. During federal fiscal year 2019, 95% of arriving refugees had 1 documented measles-containing vaccine. The program's immunization schedule included eleven vaccines preventing fourteen diseases. In 2015–2019, only two vaccine preventable disease-associated refugee group travel cancellations occurred, compared to 2–8 cancellations annually prior to program initiation. To maintain uniform standards, dedicated staff and program-specific protocols for vaccination and monitoring were introduced.

Conclusions: An overseas immunization program was successfully implemented for US-bound refugees. Due to reductions in refugee movement cancellation, lower cost of immunization overseas, and likely reductions in vaccine preventable disease-associated morbidity, we anticipate significant cost savings. Although maintaining uniform standards across diverse settings is challenging, solutions such as introduction of dedicated staff, protocol development, and ongoing technical support have ensured program cohesion, continuity, and advancement. Lessons learned can benefit similar programs implemented in the migration setting.

Keywords

Immunization programs; Refugees; Emigration and immigration

1. Background

The United States (US) resettles tens of thousands of refugees annually through the United States Refugee Admissions Program (USRAP). Numbers have ranged from 20,000 in 2018 to a peak of >200,000 in 1980 [1]. According to the 1951 United Nations Refugee Convention, a refugee is defined as someone who “owing to a well-founded fear of being persecuted for reasons of race, religion, nationality, membership of a particular social group, or political opinion, is outside the country of his nationality, and is unable to or, owing to such fear, is unwilling to avail himself of the protection of that country...”[2]. US-bound refugees' countries of origin and asylum change over time based on geopolitical conditions. In 2019, the top ten nationalities for refugees arriving in the US spanned five global regions—Africa, Asia, Europe, Latin America and the Caribbean, and the Middle East (Fig. 1). Both US-bound refugees and US-bound immigrants undergo a required health assessment, usually 3–6 months before travel to the United States. Its main purpose is to identify and treat inadmissible medical conditions of public health significance (e.g., tuberculosis disease) as defined by US regulations [3]. Persons seeking a US immigrant visa

are also legally required to receive immunizations based on the Advisory Committee for Immunization Practices (ACIP) schedule [3]. However, unlike immigrants, refugees are not legally required to receive immunizations until one year after arrival in the US, when they are eligible to become lawful permanent residents. This leaves refugees at risk of contracting vaccine preventable diseases (VPDs).

A major factor placing refugees at risk for VPDs is their variable and often limited access to immunization and other services in both home and asylum countries. Hence, VPD outbreaks have affected US-bound refugees during the resettlement process, leading to morbidity, mortality, and travel delays. For example, successive outbreaks of measles, rubella, and varicella in US-bound Liberian refugees resettling from Cote d'Ivoire resulted one child's death, the birth of an infant with severe congenital rubella syndrome, and institution of a 6-month travel suspension for refugees already living in unstable circumstances [5,6]. Instances of VPD importation have also occurred, such as measles cases in 2011 [7]. Beyond their health consequences, VPD outbreaks involve costly response activities both in the US and abroad—for example, estimated program costs reached \$300,000 during a polio outbreak in a refugee camp in Kenya, and \$130,000 during a 2011 measles outbreak affecting refugees resettling from Malaysia [8]. Such outbreaks also required CDC development of specific immunization protocols for the affected refugee groups a reactive, rather than preventive, strategy, more costly than offering routine immunization services before resettlement [9].

After arrival in the US, refugees usually undergo a second, voluntary medical assessment within 30–90 days [10]. Immunization catch-up is initiated during this assessment. However, if refugees do not have access to these ACIP-recommended immunizations until after arrival in the US, children's school entry may be delayed until immunization requirements, based on laws in the state of residence, are fully met [4]. Furthermore, domestic immunization does not prevent importation of VPDs, nor does it protect US-bound refugees before or during travel to the US.

To address these gaps, the US Centers for Disease Control and Prevention (CDC) and the US Department of State developed a pre-migration immunization program for US-bound refugees. The program was first piloted in December 2012, with the International Organization for Migration (IOM) as the major implementing partner. There was no clear precedent for such a program—which would be implemented globally, in the migration setting, and within a narrow pre-departure timeframe. Many questions were considered, including which vaccines to prioritize and how to achieve high coverage rates; how to maintain uniform program standards while retaining the flexibility to scale and adapt services to fluctuating resettlement numbers and varied settings; how to monitor immunization safety; and how to adapt patient educational materials for diverse countries, cultures, and languages.

As of September 2019, this expanding program had been implemented in over 80 countries processing US-bound refugees in Africa, the Americas, Asia, Europe, and the Middle East. We describe its key features, our response to implementation challenges, and lessons learned

about implementation of an immunization program in the setting of a planned, organized migration.

2. Methods

We describe the Vaccination Program for US-bound Refugees, including phased program implementation, schedule development, vaccine procurement, recommendations for hepatitis B surface antigen (HBsAg) testing, monitoring procedures, and programmatic challenges and solutions.

A federal fiscal year (FY) is the accounting period for the federal government, defined as the 12 months between October 1st of one calendar year and September 30th of the following calendar year [11].

Vaccine coverage rates are calculated from US refugee arrival data in CDC's Electronic Disease Notification (EDN) system. We based FY2019 immunization coverage rates on numbers of age-eligible refugees, defined as refugees born after 1956 who were 12 months old, documented in EDN to have received at least one valid dose of measles-containing vaccine by the time of departure for the US. We excluded refugees with evidence of immunity to measles (IgG testing was conducted in Ukraine only). Coverage rates for other vaccines are similarly defined based on age eligibility. As part of this program, all refugees are tested for hepatitis B virus (HBV) infection using hepatitis B surface antigen (HBsAg) testing. We excluded HBsAg-positive refugees (who therefore did not receive hepatitis B vaccine) from calculation of hepatitis B vaccination coverage rates. The prevalence of hepatitis B virus infection for FY2019 is calculated using data from IOM's Migrant Management & Operational Systems Application (MiMOSA), with number of examined refugees of all ages who tested positive for HBsAg in the numerator, and number of examined refugees receiving an HBsAg test in the denominator. Data regarding vaccine refusal are also taken from MiMOSA.

Adverse events following immunization (AEFI) data are compiled from documented AEFI reports (Appendix 5). We reviewed event type, severity, and level of management needed Appendix 5.

In the context of our program, a VPD outbreak is defined as a case or cases of a VPD occurring among, or in geographically close proximity to (e.g., same camp, city, or country—depending on the location of US-bound refugees and type of outbreak), US-bound refugees. CDC and IOM track VPD outbreaks over time; information about case importation and movement delays (meaning, halt in travel to the US for an entire refugee group, sometimes for several months, imposed in the setting of a VPD outbreak or elevated risk of such outbreak) was extracted from this information.

3. Program description

3.1. Program structure and staff training

The USRAP Vaccination Program is administered in multiple sites, across different countries and conditions, to populations that may not fall within the traditional framework

of either host/asylum country or US national immunization guidelines. As such, it can be challenging to maintain uniform program standards. An infrastructure was developed to standardize program services, including:

a. Staff—IOM appointed a global coordinator for the immunization program in 2015, as well as regional program coordinators for Africa, Asia, Europe, Latin America, and the Middle East. Coordinators disseminate guidance, conduct training and monitoring, and organize procurement. Further, sites appoint physician and nursing focal points responsible for day-to-day program management. CDC works closely with IOM coordinators on program monitoring and implementation goals, and conduct site visits to provide technical support.

b. Tools and References—The program uses a combination of newly developed and existing reference materials and guidelines. Major sources include a routinely updated program manual, and CDC’s Vaccine Storage and Handling Toolkit, which informs routine and emergency cold-chain maintenance procedures [12]. Site-specific guidance is developed by focal points and coordinators in consultation with CDC. Sites are expected to use recommended refrigerators and digital thermometers (Fig. 2). IOM recently partnered with a global supplier of cold chain monitoring solutions, providing sites in >30 countries with remote electronic temperature monitoring systems.

3.1.1. Immunization schedule—We developed a routine schedule for US-bound refugees (Table 1), based on ACIP recommendations, in close consultation with a panel of CDC vaccine subject-matter experts. US-bound refugees may be of any age at the time of the pre-migration health assessment. Further, while many children with access to camp or national Expanded Programmes on Immunization (EPI) have received at least some vaccines, not all are compatible with the ACIP schedule. Hence, our routine program schedule is essentially a catch-up schedule, designed to accommodate these unique realities.

When the program began, several ACIP-recommended vaccines were either costly (e.g., 13-valent pneumococcal conjugate vaccine [PCV-13], tetanus, diphtheria, and pertussis [Tdap], varicella) or unavailable (e.g., hepatitis A, inactivated poliovirus [IPV]) in our program sites. Hence, only seven vaccines were included in the initial schedule (Table 1). With annual updates to accommodate new ACIP recommendations, vaccine availability, and expanding program capacity, the schedule now includes 11 vaccines, preventing 14 diseases. Vaccination series in the US ACIP schedule typically include 2–5 doses of each vaccine, given over months to years. For the USRAP program, most refugees can receive up to two doses of each vaccine series within the typical timeframe of 3–6 months between the required medical examination and travel to the US. However, the number of vaccines and of doses that can be provided in each program site depends on logistics and availability.

3.1.2. Vaccine procurement—Country vaccine procurement and importation regulations vary, and affect vaccine availability in some sites. In sites where importation is possible, IOM procures vaccines from UNICEF at low cost and distributes them. One of the more costly vaccines, PCV-13, was donated by the manufacturer and distributed using this mechanism. In sites with importation restrictions, vaccines must be procured in-country

or through a combination of importation and in-country procurement. Program coordinators explore options in consultation with national and local health ministries to determine the best approach in each setting.

3.1.3. Immunization procedures and documentation—First vaccine doses are provided at the time of overseas health assessment. Medical staff first review available outside immunization records for each refugee. Valid, properly-documented immunizations (e.g., official records from camp health agencies or national immunization programs/clinics) are counted towards the USRAP schedule. Each refugee is assessed for potential vaccine-specific contraindications, such as previous severe reaction to a vaccine or vaccine component, immunocompromised status, or pregnancy (Appendix 1). Immunization orders are then placed by the examining physician and vaccines administered by medical staff.

Coordination of second doses of vaccine series is challenging in settings where IOM or panel providers have limited access to refugees after the initial health assessment. In some urban settings, refugees are asked to return to the health assessment site. In others, IOM staff travel to remote refugee camps, carrying vaccines packed in monitored cold boxes.

In some countries where IOM is not licensed to administer immunizations or lacks permanent medical staff, IOM contracts with local clinics to administer vaccines. In other such settings, program staff draft immunization orders for refugees to carry to local clinics, and update refugee immunization records at the time of departure once provided with valid documentation from the refugee.

Immunization records—including vaccines given as part of the USRAP immunization program and valid historical vaccines—are documented on official Department of State forms used during health assessment (Appendix 2). Hard copies are provided to each refugee; records are also transmitted electronically to CDC and to the receiving state by the time of arrival. CDC and state refugee health partners are piloting a process for direct importation of overseas records into state immunization registries at the time of arrival; ten states are currently participating (D. Lee and A. Dam, personal communication, October 18, 2019).

3.1.4. Implementation phases—Program implementation occurred in three phases, in order of increasing logistical complexity (Fig. 3). During the first phase, we included six countries (Thailand, Nepal, Kenya, Ethiopia, Malaysia, and Uganda) where IOM conducts the U.S-bound refugee health assessment, within established IOM clinical facilities. Until FY 2017, almost 50% of US-bound refugees were assessed in these large sites. During the second phase (FY 2016), we targeted smaller IOM programs, some lacking permanent clinics. In some such settings, IOM mobile medical teams traveled to sites to conduct the health assessment. In others, IOM medical teams were present in-country, but did not have clinical facilities; outside medical facilities were sub-contracted for immunization services, or refugees were provided vaccine requisition forms to present at outside clinics. Finally, during the third phase, we expanded the program to sites where IOM was not the designated medical provider (or “panel site”) for refugee health assessment. By the end of FY2019, non-IOM panel sites in over 50 countries had partially or fully implemented the program. Using infrastructure developed for the USRAP Vaccination Program, IOM regional hubs

supported these sites with data management and reporting, invoice reimbursement, and distribution of program materials. In selected panel sites, IOM also facilitated vaccine procurement.

3.1.5. Hepatitis B surface antigen testing—Many US-bound refugees originate in countries of intermediate or high chronic hepatitis B virus (HBV) infection prevalence (2%). Further, national HBV infection prevalence estimates may not be fully reflective of the refugee population. Based on the CDC recommendation to test all persons born in intermediate-to-high prevalence regions [13], we offer pre-vaccination hepatitis B surface antigen (HBsAg) testing to US-bound refugees, primarily using a point-of-care rapid test. HBsAg-negative individuals are provided hepatitis B vaccination (Hep B), while HBV-infected refugees are counseled about the disease, how to limit transmission, and the importance of medical follow-up after resettlement. Infection status is documented on medical records so that follow-up care can be arranged by receiving states. Symptomatic HBV-infected refugees receive additional care while overseas, if available. Household members of HBsAg-positive persons are offered the complete (3-dose) Hep B vaccination series as feasible based on their travel dates. Although ACIP recommends routine, universal Hep B vaccination through age 18 years, the USRAP schedule recommends routine vaccination for all age groups—as refugees of all ages originating in higher-prevalence countries may be at risk of infection.

HBsAg testing was incorporated into the USRAP health assessment process with relative ease, given the availability of WHO-prequalified, point-of-care test kits.

3.1.6. Informed consent, counseling, and health education materials—As part of the informed consent process occurring during health assessment, US-bound refugees are counseled about how vaccines work, which diseases the vaccines on our schedule prevent, and the benefits and risks of immunization. The text-heavy multilingual Vaccine Information Statements (VIS) used in the US presume literacy [14]. Further, HBsAg-positive refugees must receive counseling about a complex disease process [15]. Therefore, tailored educational materials had to be developed. We initially introduced a simplified VIS format (Appendix 3) and illustrated materials that could be used in either flip-chart or leaflet schemes. However, parts of this approach were suboptimal for refugees speaking languages that do not routinely use script. Therefore, IOM partnered with a public health organization to develop heavily illustrated print and video materials to capture attention and enhance understanding. These materials, vetted in focus group settings, were rolled out in all program sites (Appendix 4). Medical staff also provide verbal counseling during health assessment.

3.1.7. Immunization safety—A reporting form for adverse events following immunization (AEFI) (Appendix 5), is completed by program sites at the time of event notification, and sent to designated CDC and IOM staff, ideally within 48 h.

However, refugees may not notify program sites about every AEFI until sometime after its occurrence, since program sites are not primary care providers. Program coordinators work with CDC to discuss individual cases, and review related immunization procedures. Sites

also work to sensitize camp health agencies to notify IOM if USRAP AEFI cases present to camp clinics.

3.2. Program coverage

Nearly 320,000 US-bound refugees undergoing overseas health assessment between December 2012 and September 2019 had documentation of at least one program-related immunization. During FY2019, 94.6% of age-eligible refugee arrivals (26,949/28,478 eligible) resettled from 88 exam countries had 1 measles-containing vaccine dose documented; first-dose coverage for other vaccines ranged from 51.9% (varicella) to 91.8% (polio) (Table 2).

In general, in FY2019, immunization coverage among children was higher than coverage among adults for three vaccines given to both age groups (measles, tetanus-diphtheria, and hepatitis B) (Table 3). This is likely because many children also had access to national or camp EPI programs, with documentation of historical vaccines. Measles vaccine had the highest overall coverage among all ages, due to concerted USRAP Vaccination Program efforts to increase coverage in the setting of increasing global measles rates.

The African and Asian regions had the highest immunization coverage rates, with coverage exceeding 90% for the first dose of most vaccines, while the European region had the lowest coverage rates—except for measles-containing vaccine in children and Td vaccine in adults, for which the Middle Eastern region had lowest coverage (Table 3). Reasons for these regional discrepancies likely include lack of availability of some vaccines, depending on national regulations and importation policies (ranging from 1% unavailability for measles-containing vaccine to 27% for varicella vaccine); a higher concentration of non-IOM panel sites, adding logistical complexity and requiring additional coordination, in some regions (e.g., the Americas); and vaccine hesitancy—a concern focused mainly in the European region and described further below.

Other factors affecting vaccine coverage rates included known contraindications (up to 1% for pregnancy as a contraindication to live vaccines; <1% for any other vaccine contraindications), and, for second doses of vaccines, insufficient time interval to administer the dose before departure (from 3% for second dose of measles-containing vaccine to 41% for second dose of pneumococcal vaccine). However, sometimes there was no documented reason for non-vaccination, ranging from 1% for measles-containing vaccine to 21% for varicella vaccine.

The prevalence of positive HBsAg test results among US-bound refugees examined overseas was 2.5% overall, ranging from 0% to 10.5% in sites with at least 10 refugees examined (Fig. 4). Hepatitis B vaccine first-dose coverage rates were > 90% in nine of the ten sites with highest HBsAg prevalence; in contrast, second-dose coverage rates were below 90% in eight of these ten sites, largely due to logistical constraints such as inability to access some refugees after health assessment. Efforts to address second-dose coverage are ongoing.

Before the USRAP Vaccination Program, overseas VPD outbreaks frequently affected refugee movement. However, since the program's inception, such outbreaks have

infrequently impacted the resettlement process. For example, between 2004 and 2014, VPD outbreaks led to > 10 large-scale travel cancellations/delays (i.e., resettlement of an entire group had to be paused, sometimes for several months). At least two such outbreaks resulted in cases within the group of resettling refugees, with secondary spread during and after travel. In contrast, despite over 100 recorded instances of VPD case clusters or outbreaks overseas in communities and countries hosting US-bound refugees in and after 2015 (when the program began to expand globally (Fig. 3)), only two large-scale resettlement delays occurred: one due to a measles case in a US-bound refugee from a site which had not yet implemented the USRAP immunization program (Kyrgyzstan, 2015 [16]) and the other to a national measles outbreak in a site with high rates of vaccine hesitancy and inaccuracies in historical vaccine documentation (Ukraine, 2018). VPD case importation between 2015 and 2019 (N = 16) mostly occurred from sites where the program had not yet been implemented (n = 6/16, 37%), or for diseases with vaccines not yet included in the USRAP immunization schedule or not yet available in that site (meningococcus [n = 2, 12%], varicella [n = 1, 6%], and mumps [n = 1, 6%]; typhoid [n = 4, 25%]). No secondary spread was reported in any of these situations.

As of September 2019, by which time over 300,000 US-bound refugees had participated in the USRAP Vaccination Program, 63 people were reported to have experienced AEFIs. Most were mild, and self-limited, such as fever, rash, localized pain or swelling, or vasovagal syncope.

3.3. Response to operational challenges

Operationalizing a global immunization program inevitably involves challenges, some site-specific, and others affecting the program globally.

Site-specific operational challenges included cold chain breaches; poor internet connectivity; and vaccine delivery to remote settings. For example, a cold chain breach in a large urban site in 2015 resulted in loss of thousands of vaccine doses. In response, the site revised its cold-chain monitoring process, creating clear workflows for in-person and electronic temperature monitoring. Learning from this experience, other sites adopted similar measures and began conducting drills of their cold chain monitoring systems. Sites also included emergency backup storage arrangements in routine program planning. As discussed, a global electronic cold chain monitoring system was introduced in late 2019.

Earlier in the program's history, some remote sites relied upon centralized IOM sites to enter vaccine records into the web-based system, leading to data entry delays and incomplete records (for example: records from distant camp locations in Ethiopia were entered in the capital, Addis Ababa). Over time, as internet access expanded, connectivity issues grew less significant.

Globally, restrictions in vaccine procurement, licensure, and importation are the most significant obstacles to immunization schedule harmonization across many countries. For example, in one country, polio vaccine importation and use were reserved for ministry of health-determined purposes; our program was unable to purchase polio vaccine locally or to import it for use in US-bound refugees. These factors sometimes shift within countries

over time, requiring the program to readdress procurement avenues and readjust the schedule accordingly. The program has also been affected by intermittent vaccine shortages in some sites. Of these, we consider it a priority to address any measles-mumps-rubella (MMR) vaccine shortages, given rising global measles rates [17]. As such, measles-containing vaccine coverage rates are generally highest (Table 2). Where MMR is unavailable, we endeavor to source a measles-containing vaccine.

Global shortages in inactivated polio vaccine (IPV) also challenge the USRAP immunization program and immunization programs worldwide [18], particularly considering WHO International Health Regulation recommendations for polio vaccination during outbreaks of circulating vaccine derived type-2 poliovirus in an increasing number of countries [19].

Another challenge is systematizing management and investigation of adverse events following immunization (AEFI). Like the US Vaccine Adverse Events Reporting System, the USRAP immunization program's AEFI reporting system is passive [20]. AEFI notifications prompt reviews of immunization procedures to identify areas needing improvement. For example, the occurrence of cellulitis after vaccination in a patient led to review of infection control measures, such as handwashing and administration technique. However, the USRAP program does not fall squarely within the parameters of any national immunization program, with its attendant safety monitoring practices, where such programs exist. We are continuing to explore best practices for AEFI monitoring, notification, and response in close consultation with CDC immunization safety experts. A more comprehensive process for AEFI response is needed, including procedures to ascertain more closely whether an event is related to immunization, and guidelines for compensation and arrangement of additional medical care if needed. This is an area of growth for our program, especially as WHO AEFI monitoring efforts expand globally [21].

Despite the growth of vaccine hesitancy in the US and some other countries, it is uncommon for US-bound refugees to express vaccine hesitancy. In FY2019, 3% of US-bound refugees declined immunizations. Declinations were largely concentrated in five European sites where vaccine hesitancy is prevalent [22,23], and ranged from 10 to 34% for refugees examined in those sites. The scope of this issue may be underestimated in those sites, and in one, a nationwide measles outbreak required adoption of special guidelines for US-bound refugees, including MMR vaccination and immunity testing before travel. Reports indicate that even after arrival in the United States, some parents from this site continue to decline immunization for their children [24]. Further, although most new refugee arrivals from other sites accept immunization, some populations may later develop vaccine hesitancy based on misinformation received after arrival in the United States [22,25]. Further study is needed to understand trends in vaccine hesitancy after resettlement—which would assist our program in addressing concerns proactively, empowering US-bound refugees to make informed choices and seek out scientifically reliable health information.

4. Discussion and limitations

To our knowledge, this is the first comprehensive immunization program designed for refugees during a planned migration. The program applies an adaptation of the receiving

country's schedule across numerous overseas processing sites, for a population often falling between national boundaries. Our goal was to protect health and facilitate post-arrival integration of refugees through a cost-saving, proven public health intervention. The program is voluntary, but to-date the vast majority of US-bound refugees have agreed to participate, resulting in high vaccination coverage rates where the vaccines are available. Development of a global schedule, program infrastructure, and standardized procedures for documentation and data reporting, have enabled a degree of uniformity in program standards across global sites. Timely electronic transmission of individual immunization records to receiving US health care providers has been essential to continuity of care, and limits inadvertent revaccination after arrival.

Through the program, we are also able to offer pre-vaccination point-of-care testing for HBV infection and implement hepatitis B vaccination, an important component of both ACIP and global immunization schedules. Data indicate that HBV infection is responsible for a larger annual number of deaths than even HIV, with rising mortality rates. Our focus on identification of infected individuals and vaccination of those who are not infected—including contacts of HBV-infected refugees—align with World Health Organization goals to eliminate HBV infection as a public health threat by 2030 [26].

A limitation of our data is its partial reliance on past immunization history as recorded on official vaccination cards. In most situations, we can assume that properly documented historical records are accurate; however, there may be exceptions to this rule, as described above for one European site.

HBV infection prevalence rates are based on data from the overseas examination rather than US arrivals data, therefore representing a larger denominator. Each year, there are some refugees who undergo the overseas examination but are not cleared to travel, or leave the USRAP program altogether. However, as arriving refugees are a large subset of examined refugees, overseas prevalence rates should still closely represent prevalence amongst arrivals.

Other program goals in-progress include improving vaccine coverage rates; improving second-dose coverage for measles-containing vaccine; developing an overarching monitoring and evaluation framework; evaluating the educational materials provided to refugees; and, as discussed, developing a more comprehensive AEFI response framework.

5. Summary and conclusion

In summary, nearly 320,000 US-bound refugees have benefitted from the Vaccination Program for US-bound refugees since its inception in late 2012. As of September 2019, the program has been implemented in over 80 countries. Despite challenges inherent in introducing and expanding a complex immunization program to diverse settings across the globe, the opportunities to prevent morbidity and mortality from vaccine-preventable diseases, improve health during travel, prevent VPD importation into the United States, and reduce costs warrant these efforts. Overseas immunization can also reduce delays in school enrollment for arriving refugee children [27]. Finally, refugees are eligible to apply

for legal permanent residency in the US a year after arrival, and are required to show proof of ACIP-recommended immunizations at that juncture [28]. Providing vaccines before arrival benefits this process—especially for adults, who may be incompletely immunized after arrival if they do not establish ongoing primary healthcare [29]. Even when considering national market price variations in different sites, recent analyses indicate that this program saves \$225-\$498 per person, reflecting the lower cost of initiating the immunization schedule overseas [9]. The program is on track to reach 100% of sites processing US-bound refugees within the next year. In the wake of its success, some other resettlement countries have adopted similar immunization strategies—contributing to healthier migration and, therefore, to improved global health security. In the COVID-19 pandemic setting—which has prompted a concerning decline in global immunization coverage [30], including in the United States [31]—the USRAP Vaccination Program maintains an important role in protecting a migrating population.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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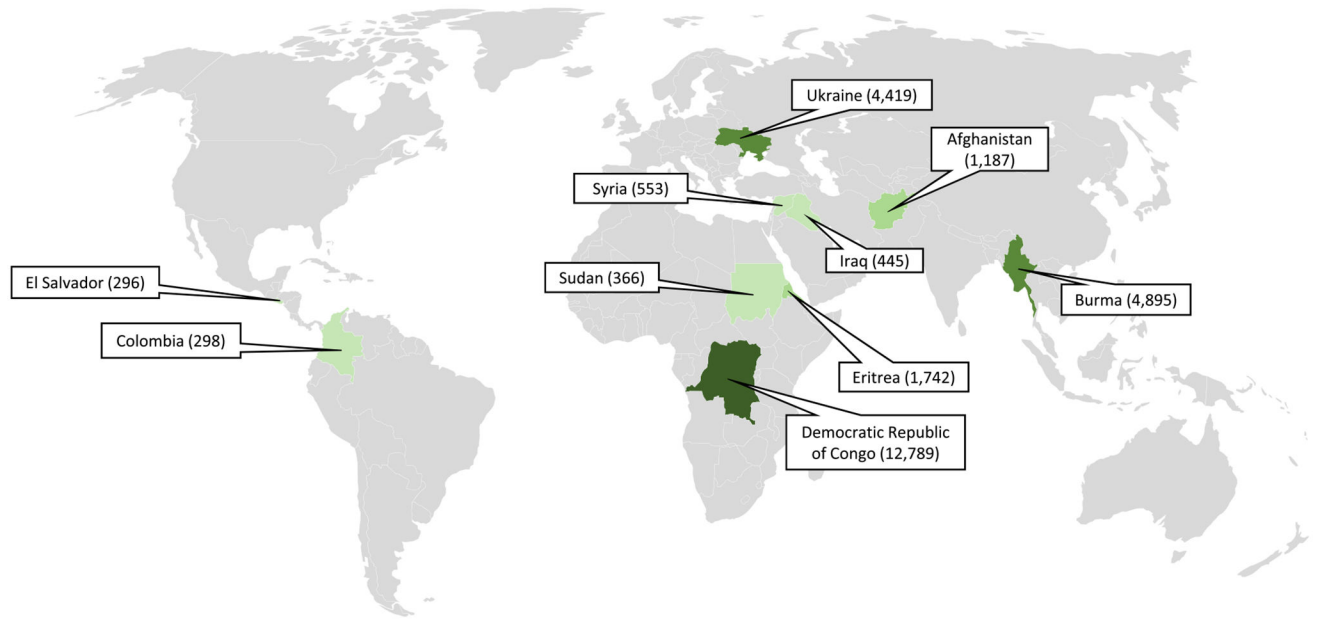
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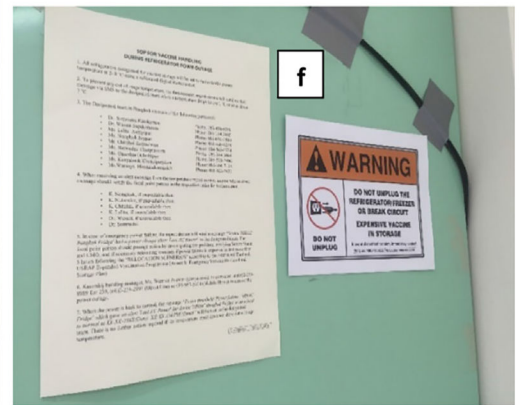
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*Countries of refugee processing/health assessment may differ from nationality of origin

Map courtesy of CDC/DGMQ. Data from CDC Electronic Disease Notification System (EDN).

Fig. 1. Top Ten Nationalities* of US Refugee Arrivals, FY 2019 N = 26,990 (91% of total FY 2019 refugee arrivals).



- a. Electronic remote temperature monitoring system
- b. Digital thermometer (calibrated)
- c. Insulation with water bottles
- d. Sheets for twice-daily in-person temperature monitoring
- e. “Do not unplug” labels at electrical outlets
- f. Emergency contact list

Fig. 2.
Vaccination Refrigerator Setup, IOM Thailand.

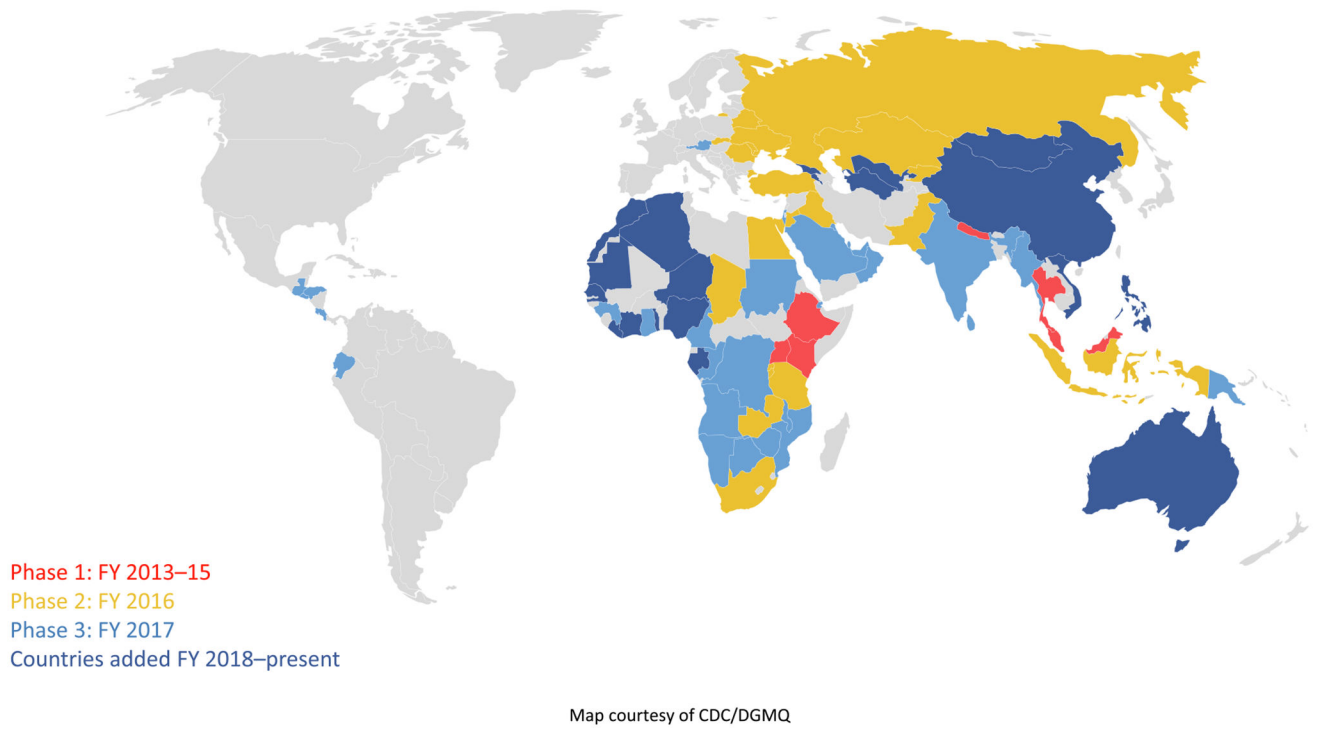


Fig. 3.
USRAP Immunization Program Implementation Phases, FY 2013–2019.

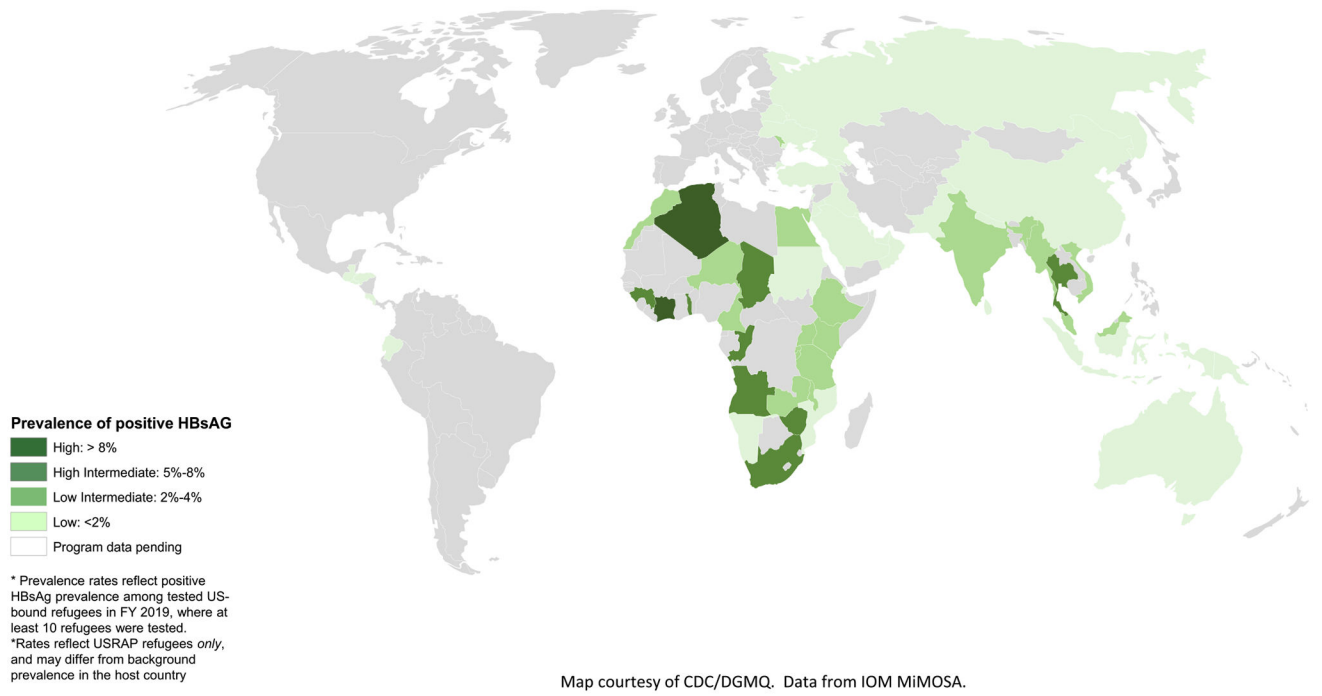


Fig. 4. HBsAg Prevalence* among US-bound Refugees, FY 2019.

Table 1

Overseas vaccination schedule for US-bound refugees, 2019.

Vaccine	Age Groups	Number of Doses
DTP or DTaP	6 weeks – <7 years	1
Hepatitis B	Birth to adulthood (all)	2 (3 if household member is HBsAg +)
Hib ⁺	6 weeks – <5 years	2 (depending on age)
MMR ⁻	1 year – born after 1956	2
bOPV ⁻ or IPV	6 weeks – <11 years	2
Pneumococcal conjugate ⁺	6 weeks – <5 years	2 (depending on age)
Rotavirus ⁻	6 weeks – 8 months	2 (max age for dose 1 is <15 wks)
Td and/or Tdap	7 years – adulthood	2 (depending on DTP/DTaP history)
Men-ACWY conjugate ⁺	11 years – <19 years	1
Varicella ⁻	1 year – <20 years	1
<i>Influenza—selected sites</i>	<i>6 months – adult</i>	<i>1–2 (depending on age)</i>

⁺ Additional doses or separate recommendations may apply for patients with certain medical conditions.

⁻ Contraindicated for immunocompromised or pregnant patients.

Table 2

Vaccination coverage^{*} for dose 1 and dose 2 of vaccines on the USRAP schedule, FY2019.

Vaccine	Dose 1 Coverage (%) ^{**}	Dose 2 Coverage (%) ^{**}
Measles	96	81
Hepatitis B	87	77
Diphtheria-Tetanus-Pertussis (DTP)	91	N/A
Tetanus-diphtheria (Td)	85	63
Polio	92	87
Pneumococcal	75	51
Hib	87	70
Rotavirus	69	58
Varicella	52	N/A
Meningococcal	(data not available) [†]	(data not available) [†]
Influenza	(data not available) [†]	(data not available) [†]

* Data from CDC Electronic Disease Notification System (EDN), reflecting refugees arriving in FY2019.

** Coverage among age-eligible refugees (measles—excludes refugees with serologic evidence of immunity; Hep B—excludes refugees who are HBsAg+).

† Data not available for newly-introduced vaccines (meningococcal), or vaccines used in specific sites only (influenza).

Table 3
 First-dose immunization coverage by region and age category*, USRAP vaccination program, FY2019.

Exam Region	DTP (6wks to 6yrs)		Tetanus-diphtheria (Td) (>6yrs)		Polio (6wks to 10yrs)		Measles (12mos to born after 1957)		Rota (6wks to 14wks + 6 days)		Hepatitis B (0 to adult)		Hib (6wks to 4yrs)		Pneumococcal (6wks to 4yrs)		Varicella (12 m-17y)	
	0-17 yrs N (%)	18+ yrs N (%)	0-17 yrs N (%)	18+ yrs N (%)	0-17 yrs N (%)	18+ yrs N (%)	0-17 yrs N (%)	18+ yrs N (%)	0-17 yrs N (%)	18+ yrs N (%)	0-17 yrs N (%)	18+ yrs N (%)	0-17 yrs N (%)	18+ yrs N (%)	0-17 yrs N (%)	18+ yrs N (%)	0-17 yrs N (%)	18+ yrs N (%)
ALL REGIONS	5917 (92%)	16,707 (87%)	8897 (92%)	13,872 (95%)	11,446 (97%)	13,872 (95%)	97 (73%)	12,889 (93%)	15,872 (82%)	4225 (88%)	4225 (78%)	4225 (88%)	4225 (78%)	4225 (88%)	4225 (78%)	4225 (88%)	4225 (78%)	12,689 (53%)
Africa	3120 (99%)	7897 (99%)	4880 (99%)	7542 (97%)	7337 (98%)	7542 (97%)	61 (79%)	7478 (99%)	7488 (99%)	2234 (99%)	2234 (95%)	2234 (99%)	2234 (95%)	2234 (99%)	2234 (95%)	2234 (99%)	2234 (95%)	7337 (62%)
Americas	116 (84%)	489 (97%)	202 (68%)	479 (94%)	308 (97%)	479 (94%)	2 (0%)	246 (96%)	381 (98%)	78 (81%)	78 (36%)	78 (81%)	78 (36%)	78 (81%)	78 (36%)	78 (81%)	78 (36%)	308 (10%)
Asia	1420 (99%)	3403 (84%)	1852 (99%)	3286 (97%)	2302 (98%)	3286 (97%)	23 (100%)	2360 (99%)	3156 (99%)	1036 (100%)	1036 (98%)	1036 (100%)	1036 (98%)	1036 (100%)	1036 (98%)	1036 (100%)	1036 (98%)	2302 (88%)
Europe	928 (65%)	3249 (85%)	1400 (70%)	1051 (96%)	596 (97%)	1051 (96%)	10 (0%)	1897 (65%)	3211 (25%)	677 (43%)	677 (6%)	677 (43%)	677 (6%)	677 (43%)	677 (6%)	677 (43%)	677 (6%)	1839 (2%)
Middle East	333 (70%)	1669 (41%)	563 (78%)	1514 (83%)	903 (87%)	1514 (83%)	1 (0%)	908 (86%)	1636 (80%)	200 (68%)	200 (45%)	200 (68%)	200 (45%)	200 (68%)	200 (45%)	200 (68%)	200 (45%)	903 (6%)

* Eligible children aged 0-17; eligible adults aged 18+ for specific vaccines with age-eligibility extending into adulthood—i.e., Td, measles-containing vaccine, and hepatitis B vaccine.