***Supplemental***

**Input Parameters for Base Case Analysis and Base Case Estimates**

Input parameters for base case analysis are summarized in Tables A1 and A2. At all four sites, children’s vaccines were provided free of charge as part of CDC’s Vaccines for Children (VFC) program. This is a federally funded CDC program that procures vaccines at a contracted rate, which is less than the average wholesale price. CDC distributes vaccines to grantees (i.e., state health departments and certain local and territorial public health agencies), which then distribute them at no charge to those private physicians' offices and public health clinics registered as VFC providers. Vaccines are provided free of charge for children who may otherwise be unable to pay. We used VFC costs published on the CDC *Vaccine Price List* archived January 5, 2015.([11](#_ENREF_11)) When there are multiple manufacturers or formulations, we applied a weighted average of available products to estimate costs as recommended (personal communication Fangjun Zhou, CDC Immunization Services Division, July 15, 2016). ([10](#_ENREF_10)) At one of the four sites (site 4), a $7 dollar surcharge was added to the listed VFC price.

For two sites, adult vaccine prices were not provided. In the absence of specific data, we assumed that the cost to clinics for adult vaccines was the midpoint of the adult Section 317 vaccine prices for uninsured adults and adult private sector prices, reported by the CDC *Vaccine Adult Price List* archived January 5, 2015;([11](#_ENREF_11)) more information about the Section 317 Immunization Program is available elsewhere.([15](#_ENREF_15)) When there were multiple manufacturers or formulations, a simple average of prices of available products was used for adults. An adult vaccine price was not reported for IPV but there is no difference in the vaccine and dose used for children so we used the average of VFC prices and private sector prices from CDC Pediatric/VFC Vaccine Price List for January 5, 2015. In addition to the listed vaccine prices for children and adults, we added a 5% correction, which was based on an assumption that 5% of doses end up unviable, either due to damage or expiration prior to administration. ([12](#_ENREF_12)) Cost estimates for each vaccine at each site are provided in Table A1.

**Table A1. Vaccine product costs at 4 U.S. sites conducting domestic medical examination of newly arrived refugees by vaccine for adults and children, 2015**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Site 1** | | **Site 2** | | **Site 3** | | **Site 4** | |
|  | Child- VFC1 | Adult (provided by Site 1) | Child- VFC1 | Adult2 | Child- VFC1 | Adults2 | Child- VFC1 + $7 | Adults (provided by Site 4) |
| Hepatitis B | $11.60 | $29.80 | $11.60 | $42.88 | $11.60 | $42.88 | $18.60 | $100 |
| Inactivated poliovirus3 | $13.08 | $23.30 | $13.08 | $20.95 | $13.08 | $20.95 | $20.08 | NA |
| Diphtheria/tetanus/pertussis-containing vaccines4 | $16.36 | $31.35 | $16.36 | $25.97 | $16.36 | $25.97 | $23.36 | $605 |
| Measles-mumps-rubella | $20.91 | $48.72 | $20.91 | $48.92 | $20.91 | $48.92 | $27.91 | $95 |
| *Haemophilus influenzae* type B | $11.05 | $10.90 | $11.05 | NA | $11.05 | NA | $18.05 | NA |
| Human papillomavirus | $126.12 | $108.975 | $126.12 | $117.58 | $126.12 | $117.58 | $133.12 | $265 |
| Hepatitis A | $16.96 | $42.80 | $16.96 | $46.57 | $16.96 | $46.57 | $23.96 | NA |
| Meningococcal | $86.23 | $75.61 | $86.23 | $99.05 | $86.23 | $99.05 | $93.23 | $200 |
| Pneumococcal | $118.06 | $61.10 | $118.06 | $126.93 | $118.06 | $126.93 | $125.06 | $115 |
| Varicella | $82.26 | $86.84 | $82.26 | $83.77 | $82.26 | $83.77 | $89.26 | $160 |

1 Weighted average price from Vaccines for Children (VFC) Price List for January 5, 2015 with a 5% correction.

2 The cost to clinics for adult vaccines was assumed to be the midpoint of the adult Section 317 vaccine prices for uninsured adults and adult private sector prices reported in the CDC A*dult Vaccine Price List* for January 5, 2015. A 5% correction was added.

3 An adult vaccine price is not reported for IPV in the CDC A*dult Vaccine Price List* but the vaccine and dose is the same for adults and children; we used the average of VFC prices and private sector prices from CDC *Pediatric/VFC Vaccine Price List* for January 5, 2015.

4 For children, DTaP prices were reported while Tdap prices were reported for adults. We assumed all children received DTaP for analyses because of limited data. However, children aged 7 years or older may receive pediatric Tdap following Advisory Committee on Immunization Practices’ (ACIP) vaccination schedule.

5 Site 4 reported prices of Tdap and Td separately. The reported price was the weighted average of Tdap ($80 per dose) and Td ($40 per dose) prices.

The vaccine administration cost per dose is summarized in Table A2. This is applied to each dose summarized in Tables 3 and 4. Note that administration fees are zero for sites 1 and 3. The comprehensive exam costs are also summarized in Table A2. The portion of the comprehensive exam attributed to vaccination was estimated based on feedback from each site.

**Table A2. Vaccine administration and comprehensive examination costs at 4 U.S. sites conducting domestic medical examination of newly arrived refugees, 2015**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **Site 1** | **Site 2** | **Site 3** | **Site 4** |
| **Variable (per dose costs)** | $0 | $15.44 | $0 | $37.50 |
| Vaccine Administration Fee (per dose) |
| **Fixed (per person costs)** |  |  |  |  |
| Comprehensive Examination Cost | $174.01 | $142.50 | $103.14 | $250 |
| Proportion of visit charge related to vaccines | $44 (25%)1 | $51 (36%)1 | $36 (35%)1 | $63 (25%)1 |

1The portion of the comprehensive exam attributed to vaccination was estimated based on feedback from each site.

The total product costs by vaccine and site are calculated by multiplying the unit product costs (Table A1) and the number of each vaccine provided (Tables 3 and 4). Vaccine administration costs are estimated by multiplying the number of doses delivered by site (for children and adults) (Table 3) by the estimated administration charge per dose (Table A2). The estimated fixed-cost estimates for the comprehensive exam are estimated by multiplying the cost per refugee (Table A2) and the number of refugees by site. These costs are summarized in Table A3.

**Table A3. Vaccine Product Costs, Administration Charges, and Fixed Exam Charges for Newly Arrived Refugees at 4 U.S. sites during 2015, by site (N=926)** 1

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **Site 1** | **Site 2** | **Site 3** | **Site 4** |
| **Variable Costs**2**:**  **Vaccine Products**  ***VPR3-provided*** |  |  |  |  |
| Hepatitis B | $2,883 | $1,268 | $2,412 | $819 |
| Inactivated poliovirus | $4,958 | $518 | $688 | $20 |
| Diphtheria/tetanus/pertussis-containing vaccines4 | $5,578 | $2,642 | $4,389 | $887 |
| Measles-mumps-rubella | $7,833 | $1,536 | $3,212 | $113 |
| *Haemophilus influenzae* type B | $188 | $177 | $77 | $0 |
| ***NonVPR3-provided*** |  |  |  |  |
| Human papillomavirus | $10,601 | $3,328 | $118 | $1,060 |
| Hepatitis A | $297 | $318 | $195 | $585 |
| Meningococcal | $6,752 | $2,009 | $789 | $0 |
| Pneumococcal | $2,312 | $3,323 | $3,595 | $585 |
| Varicella | $5,105 | $3,730 | $9,039 | $480 |
| **Vaccine Products Total (a)** | **$46,508** | **$18,850** | **$24,514** | **$3,964** |
| **Administration Charges Total (b)** | **$0** | **$6,284** | **0** | **$1,500** |
| **Variable Cost Total (a+b)** | **$46,508** | **$25,134** | **$24,514** | **$5,464** |
| **Fixed Cost5 (c):** | **$12,093** | **$18,878** | **$8,664** | **$2,500** |
| **Total Vaccination Cost (a+b+c)** | **$58,601** | **$44,012** | **$33,178** | **$7,963** |
| **Numbers of Refugees (d)** | 278 | 368 | 240 | 40 |
| **Average Vaccination Cost per Refugee (a+b+c)/(d):** | **$211** | **$120** | **$138** | **$199** |

1Values have been rounded to the nearest dollar.

2Variable costs are those dependent on the number of each vaccine provided as summarized in Table 3. Unit costs per vaccine are summarized in an online appendix. The total cost for each vaccine is all summarized in the online appendix.

3VPR is vaccination for U.S. bound refugees.

4The following diphtheria-containing vaccines were assessed: DT, DTaP, Td, Tdap.

5Fixed costs are those independent of the number of each vaccine provided and are calculated from the number of refugees (d) multiplied by the vaccination cost per refugee from Table A2.

**Lower-bound and Upper-bound Estimates**

The lower-bound and upper-bound vaccine cost estimates are summarized in Table A4. The lower-bound vaccine cost estimate for children is the weighted average VFC price for children and the upper-bound is the private sector price reported on the VFC website (*Pediatric/Vaccine Price List* for January 5, 2015). ([11](#_ENREF_11)) When there are multiple manufacturers or formulations, we again used the weighted average to estimate costs as recommended (personal communication Fangjun Zhou, CDC Immunization Services Division, date).([10](#_ENREF_10)) This adjustment was only possible for children because weighting data are not available for adults. For adults, a simple average of prices of available products was used. The lower-bound vaccine costs for adult is the adult Section 317 vaccine prices for uninsured adults and the upper-bound is the adult private sector prices reported on the CDC *Adult Vaccine Price List* archived January 5, 2015).([11](#_ENREF_11)) When adult vaccine prices were not reported on *Adult Vaccine Price List*, we used the CDC VFC prices as the lower-bound and private sector prices for children as the upper-bound (CDC *Pediatric/VFC Vaccine Price List* for January 5, 2015).([11](#_ENREF_11)) For the upper bound analysis, a 5% correction was based on an assumption that 5% of doses end up unviable (as noted for the base case analysis above). ([12](#_ENREF_12)) For the lower bound analysis, we assumed 0% wastage.

**Table A4. Lower-bound and upper-bound cost estimates for vaccinations provided to newly arrived refugees at 4 U.S. sites, by children and adults and vaccines, 2015**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Vaccines** | **Children** | | **Adults** | |
| **Lower bound1** | **Upper bound1** | **Lower bound2** | **Upper bound2** |
| Hepatitis B | $11.05 | $23.20 | $25.35 | $59.14 |
| Inactivated poliovirus | $12.46 | $28.81 | $12.46 | $28.81 |
| Diphtheria/tetanus/pertussis-containing vaccines3 | $15.58 | $24.55 | $23.61 | $41.27 |
| Measles-mumps-rubella | $19.91 | $58.95 | $37.04 | $58.95 |
| *Haemophilus influenzae* type B | $10.52 | $26.11 | NA | NA |
| Human papillomavirus | $120.11 | $160.60 | $88.90 | $141.82 |
| Hepatitis A | $16.16 | $30.63 | $25.73 | $66.11 |
| Meningococcal | $82.12 | $119.73 | $73.48 | $120.93 |
| Pneumococcal | $112.44 | $159.61 | $89.75 | $159.61 |
| Varicella | $78.34 | $98.85 | $60.76 | $98.85 |

1Lower-bound vaccine cost estimate for children is the weighted average Vaccines for Children (VFC) price for children with 0% wastage. The upper-bound is the private sector price reported on the VFC website with 5% wastage (CDC *Pediatric/Vaccine Price List archived January 5, 2015*).

2The lower bound vaccine costs for adult is the adult Section 317 vaccine prices for uninsured adults with 0% wastage, and the upper-bound is the adult private sector prices reported on the CDC *Adult Vaccine Price List* archived January 5, 2015 with 5% wastage.

3The following diphtheria-containing vaccines were assessed: DTaP (children) and Tdap (adults).

The lower-bound and upper-bound vaccine administration estimates and comprehensive examination costs are summarized in Table A5. For the sensitivity analysis of vaccine administration costs, we assumed that vaccine administration fee was always billed even for the lower-bound estimates. To estimate reimbursement rates, the Current Procedural Terminology (CPT) (13) codes that are used to report medical, surgical, and diagnostic procedures and services to entities such as physicians, health insurance companies and accreditation organizations. CPT codes 90460 and 90461 were used for children and CPT codes 90471 and 90472 were used for adults.

For children, CPT 90460 was used for each vaccine. To estimate private sector reimbursement rates, CPT 90461 was added for each component of children’s combination vaccines (e.g., DTP and MMR), which contain more than one antigen. In effect, for a vaccine with more than one antigen, the administration fee is calculated from CPT 90460 rate + (x-1) × CPT 90461 rate, where x is the number of antigens. For example, MMR has three antigens, so the administration cost was estimated by $41 + (3-1) × $26.5= $94 for upper-bound using private sector estimates in Table A5.

For adults, CPT 90471 was used for the first dose delivered during a visit and CPT 90472 was used for each additional vaccine delivered during the same visit. We estimated how many vaccines were delivered during each visit based on the totals reported by site (e.g., 4 doses for site 1 was [1 × CPT 90470 + 3 × CPT 90471] and 1 dose for site 4 is [1 × CPT 90470 + 0 × CPT 90471]).

The lower-bound estimate was based on Medicaid reimbursable rates and the upper-bound estimate was based on reported private sector reimbursement rates. For the lower-bound estimates, the Medicaid reimbursement rates were estimated based on reported Medicare reimbursement rates, which were then adjusted based on a state-specific ratio of Medicaid vs. Medicare reimbursement rates.([16](#_ENREF_16), [17](#_ENREF_17)) To estimate the national average Medicaid reimbursement rate, a weighted average of state reimbursement rates was estimated using the number of refugees that arrived in each state. For the lower-bound estimate, CPT 90461 rate was zero because the CPT code 90461 is not reimbursable for VFC services. For the upper-bound estimates, the private sector cost estimates were based on average reimbursement rates by CPT code reported in Physicians’ Fee and Coding Guide.([13](#_ENREF_13))

For the lower-bound comprehensive exam cost estimate, we assumed that 10% of one visit for the comprehensive exam would be attributed to vaccination (Table A5). For the upper-bound, 40% of one visit was attributed to vaccination activities.

**Table A5. Upper- and lower-bound estimates of vaccine administration and vaccination-attributable fraction of comprehensive examination for newly arrived refugees at 4 U.S. sites, 2015**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **Lower-bound** | | **Upper-bound** | |
| **Vaccine administration fees** | | | | |
| **Child** | | | | |
| **CPT 904601** | $17.44 | | $41.00 | |
| **CPT 90461** | $0 | | $26.50 | |
| **Adult** | | | | |
| **CPT 90471** | $17.44 | | $39.00 | |
| **CPT 90472** | $8.74 | | $26.50 | |
| **Comprehensive exam costs** | | | | |
|  | **Site 1** | **Site 2** | **Site 3** | **Site 4** |
| **Lower bound (10%)** | $17.40 | $14.25 | $10.31 | $25.00 |
| **Upper bound (40%)** | $69.60 | $57.00 | $41.26 | $100.00 |

1Current Procedural Terminology (CPT) codes, Physicians' fee and coding guide: InGuage Healthcare Solutions; 2015

For the lower-bound cost estimate, the number of refugees and vaccines (by type) reported by site (Tables 3 and 4) were multiplied by the lower-bound unit costs in Tables A4 and A5. For the upper-bound cost estimate, the number of vaccines and refugees (Tables 3 and 4) were multiplied by the upper-bound unit costs (Tables A4 and A5). The upper- and lower-bound cost estimates compared to the base case analysis are summarized in Table A6.

**Table A6: Average cost of vaccination per refugee at 4 U.S. sites during 2015, by site with sensitivity analyses (N=926, 2015 U.S. dollars)**1

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  |  | **Base** | **Lower bound2** | **Upper bound3** |
| **Site 1** | Vaccine cost | $167 | $144 | $244 |
| Administration cost | $0 | $58 | $180 |
| Visit cost | $44 | $17 | $70 |
| **Total** | **$211** | **$219** | **$494** |
| **Site 2** | Vaccine cost | $51 | $45 | $72 |
| Administration cost | $17 | $19 | $54 |
| Visit cost | $51 | $14 | $57 |
| **Total** | **$120** | **$78** | **$183** |
| **Site 3** | Vaccine cost | $102 | $87 | $145 |
| Administration cost | $0 | $39 | $120 |
| Visit cost | $36 | $10 | $41 |
| **Total** | **$138** | **$136** | **$306** |
| **Site 4** | Vaccine cost | $99 | $41 | $73 |
| Administration cost | $38 | $17 | $43 |
| Visit cost | $63 | $25 | $100 |
| **Total** | **$199** | **$83** | **$217** |

1Values have been rounded to the nearest dollar.

2Vaccine For Children (VFC) and Section 317 prices from the CDC Vaccine Price list with 0% wastage, Medicaid administration costs, and 10% of examination fee. Note that the lower bound cost for Site 1 is greater than the base case because the estimated lower bound cost for vaccine administration is greater than the base case fraction of the visit cost attributable to vaccination. However, the cost of vaccine administration are supposed to be covered in the visit fee for this site.  
3Private sector vaccine prices, private sector’s administration fees, and 40% of examination fee.

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