

## National, State, and Selected Local Area Vaccination Coverage Among Children Aged 19–35 Months — United States, 2013

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In the United States, among children born during 1994–2013, vaccination will prevent an estimated 322 million illnesses, 21 million hospitalizations, and 732,000 deaths during their lifetimes (1). Since 1994, the National Immunization Survey (NIS) has monitored vaccination coverage among children aged 19–35 months in the United States. This report describes national, regional, state, and selected local area vaccination coverage estimates for children born January 2010–May 2012, based on results from the 2013 NIS. In 2013, vaccination coverage achieved the 90% national *Healthy People 2020* target\* for  $\geq 1$  dose of measles, mumps, and rubella vaccine (MMR) (91.9%);  $\geq 3$  doses of hepatitis B vaccine (HepB) (90.8%);  $\geq 3$  doses of poliovirus vaccine (92.7%); and  $\geq 1$  dose of varicella vaccine (91.2%). Coverage was below the *Healthy People 2020* targets for  $\geq 4$  doses of diphtheria, tetanus, and pertussis vaccine (DTaP) (83.1%; target 90%);  $\geq 4$  doses of pneumococcal conjugate vaccine (PCV) (82.0%; target 90%); the full series of *Haemophilus influenzae* type b vaccine (Hib) (82.0%; target 90%);  $\geq 2$  doses of hepatitis A vaccine (HepA) (54.7%; target 85%); rotavirus vaccine (72.6%; target 80%); and the HepB birth dose (74.2%; target 85%).<sup>†</sup> Coverage remained stable relative to 2012 for all of the vaccinations with *Healthy People 2020* objectives except for increases in the HepB birth dose (by 2.6 percentage points) and rotavirus vaccination (by 4.0 percentage points). The percentage of children who received no vaccinations remained below 1.0% (0.7%). Children living

below the federal poverty level had lower vaccination coverage compared with children living at or above the poverty level for many vaccines, with the largest disparities for  $\geq 4$  doses of DTaP (by 8.2 percentage points), full series of Hib (by 9.5 percentage points),  $\geq 4$  doses of PCV (by 11.6 percentage points), and rotavirus (by 12.6 percentage points). MMR coverage was below 90% for 17 states. Reaching and maintaining high coverage across states and socioeconomic groups is needed to prevent resurgence of vaccine-preventable diseases.

NIS is a random-digit-dialed cellular<sup>§</sup> and landline telephone survey of households with children aged 19–35 months

<sup>§</sup>All identified cell telephone households were eligible for interview. Sampling weights were adjusted to correct for dual-frame (landline and cell telephone) sampling, nonresponse, noncoverage, and overlapping samples of mixed (landline and cellular) telephone users. A description of NIS dual-frame survey methodology and its effect on reported vaccination estimates is available at <http://www.cdc.gov/vaccines/imz-managers/coverage/nis/child/dual-frame-sampling.html>.

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\*Additional information is available on *Healthy People 2020* at <http://healthypeople.gov/2020/topicsobjectives2020/objectiveslist.aspx?topicid=23>.

<sup>†</sup>The *Healthy People 2020* target for the birth dose (day 0–3) of HepB is 85%, measured by annual birth cohort. In the three most recent completed birth cohorts measured by NIS, coverage with the birth dose of HepB was 65% for children born in 2008, 70.6% for children born in 2009, and 74.5% for children born in 2010.



in the 50 states, the District of Columbia, selected local areas, Guam, and the U.S. Virgin Islands (USVI).<sup>¶</sup> These household interviews are followed by a survey mailed to the child's vaccination providers (with consent of the respondent) to obtain provider-confirmed vaccination histories. Data are weighted to be representative of the population of children aged 19–35 months, and are adjusted for multiple phone lines, mixed telephone use (i.e. landline and cellular), household nonresponse, and the exclusion of phoneless households. Details regarding NIS methodology, including methods for synthesizing provider-reported immunization histories and weighting, have been described previously.<sup>\*\*</sup> The sample size of children with adequate provider data used for national estimates was 13,611, with an additional 449 children from USVI and Guam.<sup>††</sup> For completed interviews (excluding Guam and USVI), 3,152 by landline (63.5%) and 10,459 by cell phone (59.8%) had adequate vaccination data. The national Council of American

Survey Research Organization (CASRO) response rates were 62.3% for landline and 30.5% for cell phone frames.<sup>§§</sup> Coverage estimates for Hib<sup>¶¶</sup> and rotavirus<sup>\*\*\*</sup> vaccines take into account the type of vaccine used because the number of

<sup>§§</sup> The CASRO household response rate, calculated as the product of the resolution rate (percentage of the total telephone numbers called that were classified as nonworking, nonresidential, or residential), screening completion rate (percentage of known households that were successfully screened for the presence of age-eligible children), and the interview completion rate (percentage of households with one or more age-eligible children that completed the household survey). For USVI, the landline and cell phone sample CASRO rates were 72.8% and 37.2%, respectively. For Guam, the landline and cell phone sample CASRO rates were 54.6% and 29.7%, respectively. Additional information is available at <http://www.casro.org>. The CASRO response rate is equivalent to the American Association for Public Opinion Research (AAPOR) type 3 response rate. Information about AAPOR response rates is available at [http://www.aapor.org/am/template.cfm?section=standard\\_definitions1&template=/cm/contentdisplay.cfm&contented=1814](http://www.aapor.org/am/template.cfm?section=standard_definitions1&template=/cm/contentdisplay.cfm&contented=1814).

<sup>¶¶</sup> Coverage for primary Hib series was based on receipt of  $\geq 2$  or  $\geq 3$  doses, depending on product type received. The PRP-OMB Hib products require a 2-dose primary series with doses at ages 2 months and 4 months. All other Hib products require 3-dose primary series with doses at ages 2, 4, and 6 months. Coverage for the full series, which includes the primary series and a booster dose, was based on receipt of  $\geq 3$  or  $\geq 4$  doses, depending on product type received. All Hib products require a booster dose at age 12–15 months.

<sup>\*\*\*</sup> Coverage for rotavirus vaccine was based on  $\geq 2$  or  $\geq 3$  doses, depending on product type received ( $\geq 2$  doses for Rotarix [RV1], licensed in April 2008, and  $\geq 3$  doses for RotaTeq [RV5], licensed in February 2006). ACIP does not recommend using the two rotavirus vaccines interchangeably, but in the event that using more than one product cannot be avoided because of nonavailability of vaccine used to initiate series, then a total of 3 doses are required if RV5 is one of the vaccine doses (e.g., acceptable mixed series could be RV1-RV5-RV5/RV1-RV5-RV1/RV5-RV1-RV1/RV5-RV1-RV5/RV5-RV5-RV1). Additional information at <http://www.cdc.gov/mmwr/preview/mmwrhtml/rr5802a1.htm>.

<sup>¶</sup> The local areas separately sampled for the 2013 NIS included areas that receive federal Section 317 immunization funds and are included in the NIS sample every year (Chicago, Illinois; New York, New York; Philadelphia County, Pennsylvania; Bexar County, Texas; and Houston, Texas) and one additional sampled area (El Paso County, Texas). The 2013 NIS was also conducted in USVI and Guam, but these areas were excluded from national coverage estimates.

<sup>\*\*</sup> A description of the statistical methodology of the NIS is available at [ftp://ftp.cdc.gov/pub/health\\_statistics/nchs/dataset\\_documentation/nis/nispuf12\\_dug.pdf](ftp://ftp.cdc.gov/pub/health_statistics/nchs/dataset_documentation/nis/nispuf12_dug.pdf).

<sup>††</sup> Children from USVI ( $n = 201$ ) and Guam ( $n = 248$ ) were excluded from the national estimates. For completed interviews, for Guam, 63 by landline (64.3%) and 185 by cell phone (63.6%) had adequate provider data. For completed interviews, for USVI, 55 by landline (55.9%) and 146 by cell phone (49.8%) had adequate provider data.

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doses required depends on the manufacturer. Logistic regression was used to examine differences among racial and ethnic populations, controlling for poverty status. Statistical analyses were conducted using t-tests, based on weighted data and accounting for the complex survey design. A p-value of <0.05 was considered statistically significant.

## National Vaccination Coverage

In 2013, national vaccination coverage among children aged 19–35 months was 83.1% for ≥4 DTaP doses, 92.7% for ≥3 poliovirus doses, 91.9% for ≥1 MMR dose, 82.0% for the full series of Hib, 90.8% for ≥3 HepB doses, 91.2% for

≥1 varicella dose, and 82.0% for ≥4 PCV doses (Table 1). Coverage remained stable for these vaccinations relative to 2012. Coverage with the combined vaccine series<sup>†††</sup> of these vaccines was 70.4%, similar to coverage in 2012. Coverage increased from 2012 to 2013 for HepB (birth dose) (from 71.6% to 74.2%), for rotavirus vaccine (from 68.6% to

<sup>†††</sup> The combined (4:3:1:3\*:3:1:4) vaccine series includes ≥4 doses of DTaP/diphtheria and tetanus toxoids vaccine/diphtheria, tetanus toxoids, and pertussis vaccine, ≥3 doses of poliovirus vaccine, ≥1 dose of measles-containing vaccine, ≥3 or ≥4 doses of Hib (depending on product type of vaccine), ≥3 doses of HepB, ≥1 dose of varicella vaccine, and ≥4 doses of PCV.

TABLE 1. Estimated vaccination coverage among children aged 19–35 months, by selected vaccines and dosages — National Immunization Survey, United States, 2009–2013\*

Vaccine and dosage	2009		2010		2011		2012		2013	
	%	(95% CI)								
<b>DTaP</b>										
≥3 doses	95.0	(±0.6)	95.0	(±0.6)	95.5	(±0.5)	94.3	(±0.7)	94.1	(±0.9)
≥4 doses	83.9	(±1.0)	84.4	(±1.0)	84.6	(±1.0)	82.5	(±1.2)	83.1	(±1.3)
<b>Poliovirus (≥3 doses)</b>	92.8	(±0.7)	93.3	(±0.7)	93.9	(±0.6)	92.8	(±0.7)	92.7	(±1.0)
<b>MMR (≥1 dose)</b>	90.0	(±0.8)	91.5	(±0.7)	91.6	(±0.8)	90.8	(±0.8)	91.9	(±0.9)
<b>Hib<sup>†</sup></b>										
Primary series	92.1	(±0.8)	92.2	(±0.8)	94.2	(±0.6)	93.3	(±0.7)	93.7	(±0.9)
Full series	54.8	(±1.4)	66.8	(±1.3)	80.4	(±1.1)	80.9	(±1.2)	82.0	(±1.3)
<b>HepB</b>										
≥3 doses	92.4	(±0.7)	91.8	(±0.7)	91.1	(±0.7)	89.7	(±0.9)	90.8	(±1.0)
1 dose by 3 days (birth) <sup>§</sup>	60.8	(±1.3)	64.1	(±1.3)	68.6	(±1.3)	71.6	(±1.4)	74.2	(±1.4) <sup>¶</sup>
<b>Varicella (≥1 dose)</b>	89.6	(±0.8)	90.4	(±0.8)	90.8	(±0.7)	90.2	(±0.8)	91.2	(±0.9)
<b>PCV</b>										
≥3 doses	92.6	(±0.7)	92.6	(±0.8)	93.6	(±0.6)	92.3	(±0.8)	92.4	(±1.0)
≥4 doses	80.4	(±1.2)	83.3	(±1.0)	84.4	(±1.0)	81.9	(±1.1)	82.0	(±1.3)
<b>HepA</b>										
≥1 dose	75.0	(±1.1)	78.3	(±1.1)	81.2	(±1.0)	81.5	(±1.1)	83.1	(±1.2) <sup>¶</sup>
≥2 doses	46.6	(±1.4)	49.7	(±1.4)	52.2	(±1.4)	53.0	(±1.5)	54.7	(±1.6)
<b>Rotavirus**</b>	43.9	(±1.4)	59.2	(±1.4)	67.3	(±1.3)	68.6	(±1.4)	72.6	(±1.5) <sup>¶</sup>
<b>Combined series<sup>††</sup></b>	44.3	(±1.4)	56.6	(±1.3)	68.5	(±1.3)	68.4	(±1.4)	70.4	(±1.5)
<b>Children who received no vaccinations</b>	0.6	(±0.1)	0.7	(±0.2)	0.8	(±0.2)	0.8	(±0.1)	0.7	(±0.3)

**Abbreviations:** CI = confidence interval; DTaP = diphtheria, tetanus toxoids, and acellular pertussis vaccine (includes children who might have been vaccinated with diphtheria and tetanus toxoids vaccine, or diphtheria, tetanus toxoids, and pertussis vaccine); MMR = measles, mumps, and rubella vaccine; Hib = *Haemophilus influenzae* type b vaccine; HepB = hepatitis B vaccine; PCV = pneumococcal conjugate vaccine; HepA = hepatitis A vaccine.

\* For 2009, includes children born January 2006–July 2008; for 2010, children born January 2007–July 2009; for 2011, children born January 2008–May 2010; for 2012, children born January 2009–May 2011; and for 2013, children born January 2010–May 2012.

<sup>†</sup> Hib primary series: receipt of ≥2 or ≥3 doses, depending on product type received. Full series: receipt of ≥3 or ≥4 doses, depending on product type received (primary series and booster dose). Hib coverage for primary or full series not available until 2009.

<sup>§</sup> HepB administered from birth through age 3 days.

<sup>¶</sup> Statistically significant change in coverage compared with 2012 (p<0.05).

\*\* Rotavirus vaccine includes ≥2 or ≥3 doses, depending on the product type received (≥2 doses for Rotarix [RV1] or ≥3 doses for RotaTeq [RV5]).

<sup>††</sup> The combined (4:3:1:3\*:3:1:4) vaccine series includes ≥4 doses of DTaP, ≥3 doses of poliovirus vaccine, ≥1 dose of measles-containing vaccine, full series of Hib vaccine (≥3 or ≥4 doses, depending on product type), ≥3 doses of HepB, ≥1 dose of varicella vaccine, and ≥4 doses of PCV.

72.6%), and for  $\geq 1$  dose of HepA (from 81.5% to 83.1%). No change was observed in the percentage of children who received no vaccinations.

### Vaccination Coverage by Selected Demographic Characteristics

Children living below the poverty level<sup>§§§</sup> had lower coverage than children living at or above the poverty level for several vaccines, including  $\geq 3$  and  $\geq 4$  DTaP doses,  $\geq 3$  poliovirus doses, Hib (full series),  $\geq 3$  HepB doses,  $\geq 3$  and  $\geq 4$  PCV doses, rotavirus, and the combined vaccine series (Table 2). However, children living below the poverty level had higher coverage than children living at or above the poverty level for HepB (birth dose).

In 2013, black children<sup>§§§</sup> had lower coverage compared with white children for  $\geq 3$  and  $\geq 4$  DTaP doses, Hib (full series),  $\geq 4$  PCV doses, rotavirus, and the combined vaccine series (Table 2). After adjustment for poverty status, these disparities were reduced but remained statistically significant, except for the combined vaccine series. Conversely, other groups had higher coverage for various vaccines compared with white children. American Indian/Alaska Native (AI/AN) and Asian children had higher coverage than white children for  $\geq 1$  MMR dose and  $\geq 1$  varicella dose. AI/AN children also had higher coverage than white children for  $\geq 3$  HepB doses, and Asian children had higher coverage than white children for  $\geq 2$  HepA doses. Black and Hispanic children had higher coverage than white children for HepB (birth dose).

### Vaccination Coverage by State

In 2013, wide geographic variation in vaccination coverage was observed among the states (Table 3). Coverage for  $\geq 1$  MMR dose ranged from 86.0% (Colorado, Ohio, and West Virginia) to 96.3% (New Hampshire). Coverage ranged from 74.3% (Arkansas) to 93.3% (Massachusetts) for  $\geq 4$  DTaP doses, from 44.8% (Vermont) to 88.0% (Kentucky) for HepB (birth dose), from 33.6% (Wyoming) to 72.1% (Connecticut) for  $\geq 2$  HepA doses, from 56.0% (Arkansas) to 84.4% (Rhode Island) for rotavirus, and from 57.1% (Arkansas) to 82.1% (Rhode Island) for the combined vaccine series.

<sup>§§§</sup> Poverty level uses income and family size to categorize households into 1) at or above the poverty level and 2) below the poverty level. Poverty level was based on 2011 U.S. Census poverty thresholds, available at <http://www.census.gov/hhes/www/poverty/data/threshld>.

<sup>§§§</sup> Child's race/ethnicity was reported by their parent or guardian. Children categorized in this report as white, black, Asian, American Indian/Alaska Native, or multiracial were identified as non-Hispanic by their parent or guardian. Children identified as multiracial had more than one race category selected. Persons identified as Hispanic might be of any race.

### Discussion

The results of the 2013 NIS indicate that vaccination coverage among children aged 19–35 months increased relative to 2012 NIS estimates for some vaccines (rotavirus, HepB birth dose, and  $\geq 1$  HepA dose) and remained stable for the others, and less than 1% of children had not received any vaccinations. The national *Healthy People 2020* targets were met in 2013 for four vaccines ( $\geq 1$  MMR,  $\geq 3$  HepB,  $\geq 3$  poliovirus, and  $\geq 1$  varicella doses). Additionally, four vaccines were within eight percentage points of their *Healthy People 2020* targets ( $\geq 4$  DTaP doses, the full series of Hib,  $\geq 4$  PCV doses, and rotavirus), but coverage increased from 2012 to 2013 only for rotavirus vaccination. Further, disparities in coverage by poverty level were larger for these four vaccines compared with vaccines meeting their *Healthy People 2020* targets. Although coverage with  $\geq 2$  HepA doses was 30 percentage points below the 85% 2020 target and did not increase from 2012 to 2013,  $\geq 1$  HepA dose coverage increased slightly and reached 83% in 2013.

In 2012 and 2013, coverage for DTaP, PCV, and the full series of Hib remained at similar levels (81%–83%). These vaccines require a booster dose during the second year of life, when the opportunities for catch-up doses with these vaccines are fewer because of declining frequency of well-child visits. CDC recommends the use of clinician and system-based interventions to increase opportunities for vaccination, including use of immunization information systems (IIS), clinician assessment and feedback, clinician reminders, and standing orders (2).

DTaP, PCV, and Hib coverage were 8 to 12 percentage points lower for children living below the poverty level compared with children living at or above the poverty level. Parents and caregivers of children living below poverty might face additional challenges in maintaining well-child visits and thus be more likely to fall behind on booster doses. Children living below poverty also had rotavirus coverage that was 13 percentage points lower than that of children living at or above the poverty level. The first dose of rotavirus vaccine should be given before age 14 weeks and 6 days, and the final dose should be given by 8 months (3). Children living below poverty might be more likely to miss these milestones and thus not able to start or complete the series. The Vaccines for Children program likely has been successful in reducing differences in vaccination coverage between children living at or above poverty level compared with those below the poverty level for these vaccines and in removing poverty differences for vaccines such as MMR and varicella (1). To further reduce disparities, clinician and system-based interventions should be targeted to communities with a high proportion of the population living below the poverty level. Interventions to improve parental knowledge

TABLE 2. Estimated vaccination coverage among children aged 19–35 months, by selected vaccines and dosages, race/ethnicity,\* and poverty level† — National Immunization Survey, United States, 2013<sup>§</sup>

Vaccine and dosage	Race/Ethnicity							Poverty level	
	White, non-Hispanic % (95% CI)	Black, non-Hispanic % (95% CI)	Hispanic % (95% CI)	American Indian/Alaska Native only, non-Hispanic % (95% CI)	Asian, non-Hispanic % (95% CI)	Native Hawaiian or other Pacific Islander, non-Hispanic % (95% CI)	Multiracial, non-Hispanic % (95% CI)	At or Above % (95% CI)	Below % (95% CI)
<b>DTaP</b>									
≥3 doses	95.1 (±0.9)	92.4 (±2.3) <sup>¶</sup>	93.4 (±2.4)	92.4 (±6.4)	96.0 (±4.6)	NA (±NA)	92.4 (±3.6)	95.6 (±0.8)	91.2 (±2.1)**
≥4 doses	85.3 (±1.4)	74.7 (±4.2) <sup>¶</sup>	82.3 (±3.2)	78.1 (±8.8)	89.0 (±5.2)	NA (±NA)	83.1 (±4.5)	86.0 (±1.3)	77.8 (±2.7)**
<b>Poliovirus (≥3 doses)</b>	93.7 (±1.0)	91.2 (±2.6)	91.6 (±2.7)	92.2 (±6.4)	95.5 (±4.7)	NA (±NA)	90.8 (±3.7)	94.4 (±0.8)	89.2 (±2.4)**
<b>MMR (≥1 dose)</b>	91.5 (±1.1)	90.9 (±2.5)	92.1 (±2.5)	96.3 (±2.8) <sup>¶</sup>	96.7 (±1.7) <sup>¶</sup>	90.4 (±9.7)	91.5 (±3.1)	92.5 (±0.9)	90.5 (±2.1)
<b>Hib<sup>††</sup></b>									
≥3 doses	93.7 (±1.0)	90.7 (±2.5) <sup>¶</sup>	92.7 (±2.5)	89.5 (±6.8)	92.9 (±4.9)	90.5 (±9.6)	91.4 (±3.7)	94.6 (±0.8)	89.6 (±2.2)**
Primary series	94.6 (±0.8)	91.4 (±2.4) <sup>¶</sup>	93.3 (±2.4)	94.3 (±6.1)	93.8 (±4.8)	90.5 (±9.6)	92.3 (±3.6)	95.1 (±0.8)	91.0 (±2.0)**
Full series	84.2 (±1.4)	74.9 (±4.2) <sup>¶</sup>	80.9 (±3.3)	82.9 (±7.8)	82.0 (±6.2)	NA (±NA)	84.9 (±4.1)	85.3 (±1.4)	75.8 (±2.8)**
<b>HepB</b>									
≥3 doses	91.0 (±1.0)	91.1 (±2.4)	89.7 (±2.6)	96.1 (±4.3) <sup>¶</sup>	92.0 (±5.1)	94.9 (±5.6)	90.7 (±3.5)	92.0 (±0.9)	88.3 (±2.2)**
1 dose by 3 days (birth) <sup>§§</sup>	71.9 (±1.8)	76.7 (±3.7) <sup>¶</sup>	77.8 (±3.5) <sup>¶</sup>	NA (±NA)	73.7 (±6.5)	NA (±NA)	72.3 (±5.9)	72.1 (±1.7)	78.3 (±2.7)**
<b>Varicella (≥1 dose)</b>	90.0 (±1.2)	92.1 (±2.2)	92.0 (±2.5)	95.4 (±3.1) <sup>¶</sup>	96.0 (±2.0) <sup>¶</sup>	88.7 (±9.2)	91.0 (±3.0)	91.6 (±0.9)	90.3 (±2.1)
<b>PCV</b>									
≥3 doses	93.1 (±1.0)	90.8 (±2.6)	92.2 (±2.5)	92.3 (±6.1)	92.0 (±4.9)	90.9 (±8.6)	91.5 (±3.6)	94.2 (±0.8)	88.8 (±2.3)**
≥4 doses	84.1 (±1.5)	76.1 (±3.8) <sup>¶</sup>	80.4 (±3.4)	79.0 (±8.3)	85.6 (±5.4)	NA (±NA)	83.0 (±4.4)	86.1 (±1.4)	74.5 (±2.7)**
<b>HepA (≥2 doses)</b>	53.4 (±1.9)	49.1 (±4.3)	56.6 (±4.0)	NA (±NA)	67.3 (±6.8) <sup>¶</sup>	NA (±NA)	57.8 (±6.0)	56.1 (±1.9)	53.5 (±2.9)
<b>Rotavirus<sup>¶¶</sup></b>	74.8 (±1.7)	62.1 (±4.3) <sup>¶</sup>	73.7 (±3.5)	NA (±NA)	74.9 (±6.7)	NA (±NA)	72.8 (±5.3)	76.9 (±1.6)	64.3 (±2.9)**
<b>Combined series<sup>***</sup></b>	72.1 (±1.8)	65.0 (±4.4) <sup>¶</sup>	69.3 (±3.8)	70.1 (±9.2)	72.7 (±6.6)	NA (±NA)	71.8 (±5.2)	73.8 (±1.7)	64.4 (±3.0)**

**Abbreviations:** CI = confidence interval; DTaP = diphtheria, tetanus toxoids, and acellular pertussis vaccine (includes children who might have been vaccinated with diphtheria and tetanus toxoids vaccine, or diphtheria, tetanus toxoids, and pertussis vaccine); NA = not available (estimate not available if the unweighted sample size for the denominator was <30 or 95% CI half width / estimate >0.588 or 95% CI half width was ≥10); MMR = measles, mumps, and rubella vaccine; Hib = *Haemophilus influenzae* type b vaccine; HepB = hepatitis B vaccine; PCV = pneumococcal conjugate vaccine; HepA = hepatitis A vaccine.

\* Children's race/ethnicity was reported by parent or guardian. Children identified in this report as white, black, Asian, American Indian/Alaska Native, Native Hawaiian or other Pacific Islander, or multiracial were reported by the parent or guardian as non-Hispanic. Children identified as multiracial had more than one race category selected. Children identified as Hispanic might be of any race.

† Children were classified as below poverty if their total family income was less than the poverty threshold specified for the applicable family size and number of children aged <18 years. Children with total family income at or above the poverty threshold specified for the applicable family size and number of children aged <18 years were classified as at or above poverty. A total of 535 children with adequate provider data and missing data on income were excluded from the analysis. Poverty thresholds reflect yearly changes in the Consumer Price Index. Additional information available at <http://www.census.gov/hhes/www/poverty.html>.

§ Children in the 2013 National Immunization Survey were born January 2010–May 2012.

¶ Statistically significant difference ( $p < 0.05$ ) in estimated vaccination coverage by race/ethnicity. Children identified as non-Hispanic white were the reference group.

\*\* Statistically significant difference ( $p < 0.05$ ) in estimated vaccination coverage by poverty level. Children living at or above poverty were the reference group.

†† Hib primary series: receipt of ≥2 or ≥3 doses, depending on product type received; full series: primary series and booster dose includes receipt of ≥3 or ≥4 doses, depending on product type received.

§§ HepB administered from birth through age 3 days.

¶¶ Includes ≥2 or ≥3 doses, depending on product type received (≥2 doses for Rotarix [RV1] or ≥3 doses for RotaTeq [RV5]).

\*\*\* The combined (4:3:1:3\*:3:1:4) vaccine series includes ≥4 doses of DTaP, ≥3 doses of poliovirus vaccine, ≥1 dose of measles-containing vaccine, full series of Hib vaccine (≥3 or ≥4 doses, depending on type), ≥3 doses of HepB, ≥1 dose of varicella vaccine, and ≥4 doses of PCV.

about vaccines and to further facilitate access to vaccinations can also help to reduce disparities in coverage.

Despite a national MMR vaccination coverage level of 91.9%, one child in 12 in the United States is not receiving their first dose of MMR vaccine on time, underscoring considerable measles susceptibility across the country. Vaccination coverage continued to vary by state. In 2013, there were 10 states with ≥1 MMR dose coverage levels ≥95%, and 17 states with ≥1 MMR dose coverage below the *Healthy People 2020* target of 90%. Through August 8, 2014, a total of 593 measles cases

had been reported from 21 states, the highest number reported in the United States since measles was declared eliminated in the United States in 2000; most cases have occurred in persons who were unvaccinated or had unknown vaccination status; updated provisional case counts are available at <http://www.cdc.gov/measles/index.html>. Given the large number of cases this year and the continuing risk for importation, clinicians should have a heightened awareness of the potential for measles in their communities and the importance of vaccination to prevent measles. Communities with lower MMR coverage

TABLE 3. Estimated vaccination coverage with selected individual vaccines and a combined vaccine series\* among children aged 19–35 months, by U.S. Department of Health and Human Services (HHS) region and state and local area — National Immunization Survey, United States, 2013†

HHS region, state and local area	MMR (≥1 dose)		DTaP (≥4 doses)		Hep B (birth) <sup>§</sup>		HepA (≥2 doses)		Rotavirus <sup>¶</sup>		Combined vaccine series*	
	%	(95% CI)	%	(95% CI)	%	(95% CI)	%	(95% CI)	%	(95% CI)	%	(95% CI)
<b>United States overall</b>	<b>91.9</b>	<b>(±0.9)</b>	<b>83.1</b>	<b>(±1.3)</b>	<b>74.2</b>	<b>(±1.4)**</b>	<b>54.7</b>	<b>(±1.6)</b>	<b>72.6</b>	<b>(±1.5)**</b>	<b>70.4</b>	<b>(±1.5)</b>
<b>HHS Region I</b>	<b>94.2</b>	<b>(±2.2)</b>	<b>90.9</b>	<b>(±2.5)</b>	<b>74.6</b>	<b>(±3.7)</b>	<b>63.2</b>	<b>(±4.4)</b>	<b>81.4</b>	<b>(±3.5)</b>	<b>77.1</b>	<b>(±3.7)</b>
Connecticut	91.4	(±5.4)	88.0	(±5.9)	75.2	(±7.5)	72.1	(±7.5)	81.1	(±6.3)	78.2	(±6.8)
Maine	91.0	(±4.5)	87.9	(±5.7)	68.9	(±7.4)	57.4	(±7.7)	72.0	(±7.1)	68.0	(±7.5)
Massachusetts	95.8	(±3.6)	93.3	(±4.0)	78.0	(±6.4)	62.7	(±8.0)	84.0	(±6.3)	78.5	(±6.6)
New Hampshire	96.3	(±2.6)	91.3	(±3.9)	74.1	(±6.5)	53.3	(±7.7)	78.2	(±6.7)	74.9	(±6.8)
Rhode Island	95.6	(±3.3)	91.6	(±4.9)	72.7	(±7.0)	60.9	(±8.2)	84.4	(±6.2)	82.1	(±6.7)**
Vermont	91.2	(±4.0)	85.8	(±5.1)	44.8	(±6.8)	48.5	(±6.8)**	73.4	(±6.1)**	66.9	(±6.6)
<b>HHS Region II</b>	<b>95.5</b>	<b>(±1.9)**</b>	<b>86.5</b>	<b>(±3.1)</b>	<b>62.5</b>	<b>(±4.2)</b>	<b>49.3</b>	<b>(±4.4)</b>	<b>72.3</b>	<b>(±4.0)**</b>	<b>72.4</b>	<b>(±4.1)**</b>
New Jersey	95.6	(±3.3)	86.4	(±5.3)	59.8	(±7.2)	51.2	(±7.4)	69.0	(±6.9)	72.9	(±6.8)
New York	95.5	(±2.3)**	86.6	(±3.8)	63.7	(±5.2)	48.4	(±5.5)	73.8	(±4.8)**	72.2	(±5.0)**
City of New York	96.8	(±2.5)**	86.0	(±5.3)	61.2	(±7.1)	49.4	(±7.3)	67.0	(±7.1)**	69.8	(±6.9)
Rest of state	94.2	(±3.9)	87.2	(±5.5)	66.3	(±7.6)	47.3	(±8.2)	80.7	(±6.4)	74.6	(±7.4)**
<b>HHS Region III</b>	<b>92.1</b>	<b>(±2.6)</b>	<b>85.2</b>	<b>(±3.4)</b>	<b>77.9</b>	<b>(±3.8)</b>	<b>55.1</b>	<b>(±4.3)</b>	<b>77.8</b>	<b>(±3.7)**</b>	<b>73.1</b>	<b>(±4.0)</b>
Delaware	94.8	(±3.4)	87.9	(±5.0)	83.6	(±5.3)**	64.2	(±7.0)	83.9	(±5.6)	71.8	(±6.6)
District of Columbia	96.2	(±3.1)	86.2	(±5.8)	78.3	(±6.9)	66.2	(±8.4)	68.4	(±8.1)**	76.9	(±7.2)
Maryland	95.3	(±4.4)	87.4	(±6.5)	75.4	(±7.7)	55.6	(±9.2)	83.7	(±6.6)**	75.8	(±8.0)
Pennsylvania	93.3	(±3.2)**	88.7	(±3.9)**	83.3	(±4.3)	58.3	(±5.8)	77.2	(±5.3)	75.5	(±5.2)
Philadelphia	95.9	(±2.7)	88.7	(±4.5)	77.9	(±5.9)	59.5	(±7.2)	73.4	(±6.4)	76.7	(±6.4)
Rest of state	92.8	(±3.8)**	88.7	(±4.5)**	84.4	(±5.0)	58.1	(±6.7)	78.0	(±6.2)	75.3	(±6.1)
Virginia	88.6	(±7.0)	78.8	(±9.3)	72.3	(±10.2)	48.0	(±10.8)	76.2	(±9.2)	69.2	(±10.0)
West Virginia	86.0	(±5.8)	83.4	(±6.2)	73.9	(±7.9)	57.5	(±8.4)	68.4	(±7.8)	65.5	(±7.9)
<b>HHS Region IV</b>	<b>93.0</b>	<b>(±1.7)</b>	<b>82.8</b>	<b>(±3.0)</b>	<b>73.5</b>	<b>(±3.3)</b>	<b>51.3</b>	<b>(±3.4)</b>	<b>68.9</b>	<b>(±3.4)</b>	<b>70.8</b>	<b>(±3.5)</b>
Alabama	89.7	(±5.8)	84.0	(±7.3)	81.7	(±7.1)	59.2	(±8.9)	74.8	(±7.8)	77.0	(±7.8)
Florida	93.4	(±4.0)	80.3	(±7.7)	58.0	(±8.3)	48.7	(±8.0)	66.0	(±8.1)	70.0	(±8.7)
Georgia	93.9	(±4.1)	83.5	(±7.9)	76.4	(±8.8)**	58.0	(±10.1)	64.6	(±10.2)	69.8	(±9.8)
Kentucky	89.5	(±5.1)	84.1	(±6.4)	88.0	(±5.6)	41.4	(±8.6)	66.4	(±8.5)	72.7	(±8.0)
Mississippi	95.2	(±3.0)	87.4	(±5.4)	79.2	(±7.1)	39.1	(±8.8)	63.2	(±8.6)	74.6	(±7.7)
North Carolina	96.0	(±3.3)**	87.5	(±5.3)	82.1	(±6.1)	51.6	(±7.7)	75.4	(±7.2)	72.0	(±7.5)
South Carolina	89.2	(±5.3)	77.3	(±7.5)	76.1	(±7.4)	52.5	(±8.8)	69.9	(±8.2)	66.5	(±8.3)
Tennessee	92.3	(±4.4)	81.1	(±6.0)	76.6	(±5.8)	52.6	(±7.1)	73.3	(±7.2)	68.5	(±6.8)
<b>HHS Region V</b>	<b>90.1</b>	<b>(±1.9)</b>	<b>81.6</b>	<b>(±2.5)</b>	<b>76.5</b>	<b>(±2.6)</b>	<b>53.0</b>	<b>(±3.0)</b>	<b>70.9</b>	<b>(±2.8)</b>	<b>68.0</b>	<b>(±2.9)</b>
Illinois	91.4	(±3.1)	82.7	(±4.5)	71.4	(±5.1)	48.4	(±5.5)	72.6	(±5.0)	66.8	(±5.3)
City of Chicago	90.0	(±5.2)	82.0	(±7.3)	78.9	(±8.2)	43.6	(±9.3)	76.1	(±7.7)	64.4	(±8.5)
Rest of state	91.9	(±3.8)	83.0	(±5.5)	68.7	(±6.2)	50.1	(±6.7)	71.4	(±6.2)	67.7	(±6.5)
Indiana	92.0	(±3.6)	82.1	(±5.3)	82.8	(±5.7)	61.0	(±6.9)**	65.7	(±7.1)	68.5	(±6.7)
Michigan	89.2	(±5.1)	79.6	(±6.6)	82.5	(±6.1)	51.2	(±7.9)	70.1	(±7.2)	70.0	(±7.4)
Minnesota	90.8	(±5.5)	90.5	(±5.0)	63.8	(±8.6)	54.3	(±9.1)	80.3	(±6.9)	74.1	(±7.8)
Ohio	86.0	(±5.2)	75.8	(±7.0)	78.1	(±6.4)	49.2	(±7.6)	66.5	(±7.5)	61.7	(±7.5)
Wisconsin	93.2	(±4.2)	84.0	(±6.1)	80.5	(±6.0)	63.2	(±7.5)	73.6	(±6.9)	72.8	(±7.1)

See table footnotes on page 747.

are more vulnerable to measles transmission. Outbreaks of measles most commonly occur in communities with pockets of persons who were unvaccinated because of philosophic or religious beliefs (4). Pockets of unvaccinated persons also occur in states with high vaccination coverage, highlighting the importance of state health departments assessing measles susceptibility at the local level.

State and local health departments can identify communities with lower MMR and other vaccination rates among children using IIS (5). Based on 2012 reports from 54 of 56 state and local immunization awardees, 86% of U.S. children aged <6 years participated in IIS (5), which are effective in increasing vaccination rates through their capabilities for 1) generating

patient reminder and recall notifications, enabling clinician assessment and feedback, and providing clinician reminders; 2) determining patient vaccination status for decisions made by clinicians, health departments, and schools; 3) guiding public health responses to outbreaks of vaccine-preventable disease; 4) informing assessments of vaccination coverage by examining missed vaccination opportunities and disparities in vaccination coverage; and 5) facilitating vaccine management and accountability (2). The full potential of IIS can be achieved by meeting or exceeding new functional standards for IIS developed by CDC for 2013–2017 and fully utilizing IIS for program planning, implementation, and evaluation (5). In addition to IIS, other sources of information on local

**TABLE 3. (Continued) Estimated vaccination coverage with selected individual vaccines and a combined vaccine series\* among children aged 19–35 months, by U.S. Department of Health and Human Services (HHS) region and state and local area — National Immunization Survey, United States, 2013†**

HHS region, state and local area	MMR (≥1 dose)		DTaP (≥4 doses)		Hep B (birth) <sup>§</sup>		HepA (≥2 doses)		Rotavirus <sup>¶</sup>		Combined vaccine series*	
	%	(95% CI)	%	(95% CI)	%	(95% CI)	%	(95% CI)	%	(95% CI)	%	(95% CI)
<b>HHS Region VI</b>	<b>91.5</b>	<b>(±2.1)</b>	<b>80.4</b>	<b>(±3.2)</b>	<b>80.5</b>	<b>(±2.8)**</b>	<b>58.9</b>	<b>(±3.8)</b>	<b>70.5</b>	<b>(±3.8)</b>	<b>69.8</b>	<b>(±3.6)</b>
Arkansas	88.3	(±5.9)	74.3	(±8.3)	79.7	(±7.3)	35.8	(±7.9)	56.0	(±9.0)	57.1	(±8.9)
Louisiana	88.1	(±5.1)	78.5	(±6.4)	81.6	(±5.7)	50.4	(±7.7)	69.6	(±7.3)	69.1	(±7.5)
New Mexico	89.1	(±4.6)	79.8	(±6.4)	67.5	(±7.0)	49.3	(±7.5)	68.7	(±7.0)**	65.7	(±7.2)
Oklahoma	89.8	(±3.8)	79.2	(±5.4)	76.7	(±5.4)**	51.8	(±6.5)	58.8	(±6.4)	62.7	(±6.3)
Texas	92.7	(±2.8)	81.5	(±4.5)	81.8	(±3.9)**	64.2	(±5.3)**	73.8	(±5.2)	72.5	(±5.0)**
Bexar County	93.0	(±3.7)	79.4	(±6.5)	73.0	(±6.9)	64.3	(±7.2)	67.2	(±7.5)	70.6	(±7.1)
City of Houston	92.4	(±4.5)	85.0	(±6.3)	83.2	(±7.9)	65.8	(±9.0)	80.8	(±7.6)	77.6	(±7.4)
El Paso County	93.7	(±3.3)**	76.7	(±6.1)	74.5	(±6.2)	64.8	(±6.8)	70.6	(±6.7)	69.7	(±6.6)
Rest of state	92.7	(±3.5)	81.4	(±5.7)	82.7	(±4.8)**	63.9	(±6.7)	73.5	(±6.6)**	72.0	(±6.3)**
<b>HHS Region VII</b>	<b>91.1</b>	<b>(±2.7)</b>	<b>84.5</b>	<b>(±3.3)</b>	<b>79.1</b>	<b>(±3.5)</b>	<b>54.9</b>	<b>(±4.5)</b>	<b>73.5</b>	<b>(±4.0)</b>	<b>71.9</b>	<b>(±4.0)</b>
Iowa	94.5	(±3.9)	89.6	(±4.4)	79.5	(±7.2)**	57.5	(±8.6)	74.7	(±8.2)	78.3	(±6.7)
Kansas	89.4	(±4.7)	81.6	(±6.1)	77.2	(±6.5)	60.2	(±7.6)	72.6	(±6.9)**	68.7	(±7.1)
Missouri	89.8	(±5.3)	82.1	(±6.6)	79.2	(±6.3)	45.9	(±8.5)	72.4	(±7.5)	67.9	(±7.7)
Nebraska	92.5	(±4.1)	88.3	(±4.7)	81.3	(±5.3)	69.5	(±6.5)	76.2	(±6.2)	79.0	(±5.9)
<b>HHS Region VIII</b>	<b>89.2</b>	<b>(±2.7)</b>	<b>84.2</b>	<b>(±3.0)</b>	<b>70.4</b>	<b>(±3.7)</b>	<b>54.5</b>	<b>(±4.0)</b>	<b>74.1</b>	<b>(±3.5)</b>	<b>71.4</b>	<b>(±3.7)</b>
Colorado	86.0	(±5.5)	81.2	(±6.0)	60.2	(±7.3)	47.6	(±7.4)	73.8	(±6.6)	69.2	(±6.9)
Montana	87.3	(±5.2)	79.0	(±6.4)	73.9	(±6.8)	46.4	(±8.5)	65.5	(±8.2)	65.4	(±8.1)
North Dakota	91.4	(±3.8)	78.6	(±5.9)	82.0	(±5.9)	59.5	(±6.8)	78.4	(±5.4)	72.0	(±6.2)
South Dakota	93.1	(±4.4)	86.5	(±5.8)	70.9	(±7.8)	55.4	(±8.3)	68.7	(±7.8)	73.8	(±7.7)**
Utah	92.6	(±3.6)	90.3	(±4.1)**	81.2	(±5.5)	67.6	(±6.8)**	78.3	(±5.8)	75.2	(±6.1)
Wyoming	89.0	(±5.4)	80.9	(±6.6)	67.0	(±8.0)	33.6	(±7.6)	65.7	(±8.0)	70.0	(±7.7)
<b>HHS Region IX</b>	<b>90.8</b>	<b>(±4.2)</b>	<b>82.1</b>	<b>(±5.1)</b>	<b>71.9</b>	<b>(±6.1)</b>	<b>56.8</b>	<b>(±6.7)</b>	<b>75.1</b>	<b>(±5.7)</b>	<b>68.2</b>	<b>(±6.2)</b>
Arizona	91.4	(±3.7)	76.6	(±6.6)	79.1	(±5.8)	55.4	(±8.1)	70.9	(±7.5)	65.1	(±7.7)
California	90.7	(±5.3)	83.1	(±6.4)	70.3	(±7.7)	56.8	(±8.4)	76.8	(±7.2)	69.3	(±7.8)
Hawaii	92.8	(±3.8)	83.7	(±6.1)	77.3	(±6.7)	54.2	(±8.0)	73.3	(±6.9)	66.5	(±8.2)**
Nevada	90.4	(±3.5)	81.1	(±5.0)	75.4	(±5.6)	61.1	(±6.4)	62.1	(±6.5)	60.6	(±6.4)
<b>HHS Region X</b>	<b>91.9</b>	<b>(±2.5)**</b>	<b>81.2</b>	<b>(±4.1)</b>	<b>71.6</b>	<b>(±4.3)</b>	<b>56.2</b>	<b>(±5.0)</b>	<b>72.1</b>	<b>(±4.4)</b>	<b>69.2</b>	<b>(±4.6)</b>
Alaska	90.5	(±3.6)	75.5	(±6.1)	59.4	(±7.0)	52.5	(±7.2)	64.2	(±6.8)	63.9	(±6.8)
Idaho	91.1	(±4.3)	84.2	(±5.3)	72.7	(±6.5)	60.7	(±7.3)	74.6	(±6.4)	70.2	(±6.9)
Oregon	89.4	(±4.4)	83.8	(±5.2)	66.8	(±6.3)	55.9	(±6.7)	64.3	(±6.7)	66.6	(±6.5)
Washington	93.5	(±3.9)**	79.8	(±7.0)	75.0	(±7.1)	55.7	(±8.4)	76.3	(±7.3)	70.8	(±7.8)
<i>Range</i>	<i>(86.0–96.3)</i>		<i>(74.3–93.3)</i>		<i>(44.8–88.0)</i>		<i>(33.6–72.1)</i>		<i>(56.0–84.4)</i>		<i>(57.1–82.1)</i>	
<b>Territories</b>												
Guam	84.9	(±5.5)	71.5	(±7.2)	87.7	(±4.7)	45.8	(±7.5)	8.0	(±3.8)	50.3	(±7.8)
U.S. Virgin Islands	59.0	(±8.7)	51.1	(±8.8)	78.5	(±6.6)	18.6	(±6.5)	23.7	(±7.8)	39.8	(±8.5)

**Abbreviations:** MMR = measles, mumps, and rubella vaccine; DTaP = diphtheria, tetanus toxoids, and acellular pertussis vaccine (includes children who might have been vaccinated with, diphtheria and tetanus toxoids vaccine, or diphtheria, tetanus toxoids, and pertussis vaccine; HepB = hepatitis B vaccine; HepA = hepatitis A vaccine; CI = confidence interval; Hib = *Haemophilus influenzae* type b vaccine; PCV = pneumococcal conjugate vaccine.

\* The combined (4:3:1:3\*:3:1:4) vaccine series includes ≥4 doses of DTaP, ≥3 doses of poliovirus vaccine, ≥1 dose of measles-containing vaccine, full series of Hib vaccine (≥3 or ≥4 doses, depending on product type), ≥3 doses of HepB, ≥1 dose of varicella vaccine, and ≥4 doses of PCV.

† Children in the 2013 National Immunization Survey were born January 2010–May 2012.

§ HepB administered from birth through age 3 days.

¶ Either ≥2 or ≥3 doses of rotavirus vaccine, depending on product type received (≥2 doses for Rotarix [RV1] or ≥3 doses for RotaTeq [RV5]).

\*\* Statistically significant increase in coverage compared with 2012 estimates from the National Immunization Survey (p<0.05).

coverage that might be available include school or community level data from monitoring school vaccination requirements (6) and county level estimates from NIS (7). Taken together, local coverage estimates from IIS and other sources can provide critical data to inform programs and interventions at the county level that might subsequently further increase vaccination coverage.

The findings in this report are subject to at least three limitations. First, the household response rates for landline

and cell phone samples were 62.3% and 30.5%, respectively. Furthermore, only 63.5% of landline and 59.8% of cell phone completed interviews had adequate vaccination data. Thus, estimates might have been biased, even after sample weights were adjusted to combine landline and cell samples and adjusted to correct for nonresponse, exclusion of households without telephones, and overlapping samples of mixed (landline and cell) telephone users. Results are weighted to key population controls. Although weighting does not guarantee against

**What is already known on this topic?**

*Healthy People 2020* has set childhood vaccination targets of 90% for  $\geq 1$  dose measles, mumps, and rubella vaccine,  $\geq 3$  doses of hepatitis B vaccine,  $\geq 3$  doses of poliovirus vaccine,  $\geq 1$  dose of varicella vaccine,  $\geq 4$  doses of diphtheria, tetanus, and pertussis vaccine,  $\geq 4$  doses of pneumococcal conjugate vaccine, and the full series of *Haemophilus influenzae* type b vaccine. For these and other vaccines, the National Immunization Survey estimates coverage among U.S. children aged 19–35 months.

**What is added by this report?**

In 2013, childhood vaccination coverage remains near or above national target levels for  $\geq 1$  dose of measles, mumps, and rubella vaccine (91.9%),  $\geq 3$  doses of hepatitis B vaccine (90.8%),  $\geq 3$  doses of poliovirus vaccine (92.7%), and  $\geq 1$  dose of varicella vaccine (91.2%); however, coverage varied by state, and differences in coverage by income persist.

**What are the implications for public health practice?**

To sustain high coverage and improve coverage for more recently recommended vaccines and those that require booster doses after age 12 months, efforts are needed by parents, clinicians, health systems, and local and state health departments to implement interventions recommended by the *Guide to Community Preventive Services*. Further development and use of immunization information systems by state and local health departments can further identify local pockets of undervaccinated children to ensure that all children remain adequately protected.

bias, it does mitigate and minimize the bias. Second, although response rates are within 1–3 percentage points of previous year and weights have been adjusted to reflect the increasing prevalence of cell-only households over time, nonresponse bias might have changed over time, which could affect interpretation of comparisons across data years. Analyses of total survey error for the NIS for 2010,\*\*\*\* 2011 and 2012 (through June) indicated bias in estimates attributable to incomplete sample frame and selection bias was low, on the order of less than two percentage points (8). Future analyses will quantify the amount of bias that might be occurring in later years of NIS data. Third, NIS estimates of  $\geq 2$  HepA doses might underestimate coverage of children before age 3 years. The first dose of HepA is recommended during age 12–23 months, and the second dose is recommended at 6–18 months after the first dose (3). Children's vaccination status in NIS is determined up to age 19–35 months, so some children might have received their second dose, or be due to receive their second dose, after the survey was conducted.

\*\*\*\* Additional information available at <http://www.amstat.org/meetings/jsm/2012/onlineprogram/abstractdetails.cfm?abstractid=304324>.

Coverage for many childhood vaccinations during 1994–2013 at, near, or above 90% has contributed to low levels of most vaccine-preventable diseases and estimated net savings of \$1.38 trillion in total societal costs over the lifetimes of children born during that period (1). Results of the 2013 NIS indicate sustained high vaccination coverage and low proportion of children aged 19–35 months who have not received any vaccinations. Established in 1994 and reaching its 20th year in 2013, the NIS will continue to monitor coverage levels overall and in subpopulations (e.g., by poverty status, race/ethnicity, state, and selected local areas) to identify gaps in vaccination coverage. Further development and use of IIS by state and local health departments can further identify local pockets of undervaccinated children to ensure that all children remain adequately protected. To sustain high coverage and improve coverage for more recently recommended vaccines and those that require booster doses after age 12 months, efforts are needed by parents, clinicians, health systems, and local and state health departments to implement the interventions recommended by the *Guide to Community Preventive Services* (2). In addition to use of IIS, these interventions are aimed at increasing community demand for vaccination, enhancing access to health services, and implementing provider- and system-based interventions.

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## Assessment of Rabies Exposure Risk in a Group of U.S. Air Force Basic Trainees — Texas, January 2014

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In January 2014, members of the Joint Base San Antonio (JBSA)-Lackland, Texas, preventive medicine and public health teams evaluated a U.S. Air Force basic training squadron for potential exposure in sleeping bays to rabies virus carried by Mexican free-tailed bats (*Tadarida brasiliensis*). Exposure to bats while asleep or otherwise unaware is an important risk factor for rabies in the United States. Over the past several decades, most indigenous human rabies infections in the United States have resulted from the bite of an infected bat (1), and the bite was not reported in more than half of the cases (2). Mexican free-tailed bats in Texas often carry rabies virus. Among 8,904 bats tested during 2001–2010, a total of 1,558 (18%) tested positive for rabies (3). To assess the risk to the Air Force trainees and identify those for whom rabies postexposure prophylaxis (PEP) might be indicated, Lackland preventive medicine and public health teams interviewed 922 persons (866 trainees and 56 instructors) and determined that PEP, consisting of human rabies immune globulin and the 4-dose vaccination series given over 14 days (1,4), was indicated for 200 persons (22%). This report describes the public health response to a mass indoor exposure to bats, including group-based rabies risk stratification, adverse reactions to PEP, and infestation remediation. These interventions can be considered for future mass exposures to bats.

### Investigation and Results

Each year, approximately 35,000 recruits join the U.S. Air Force by completing the 8.5-week basic military training course at JBSA-Lackland in San Antonio, Texas. Because of aging infrastructure, new buildings are being constructed on the base for basic training. However, currently some of the training squadrons inhabit new buildings and some are housed in older buildings. Each of the older buildings has 20 dormitories, and each dormitory accommodates one flight of up to 60 trainees in two large sleeping bays (Figure); a flight is the smallest organizational unit in the U.S. Air Force.

On January 17, 2014, during an inspection of an older building for an unrelated health concern by the Lackland preventive medicine and public health teams, a few trainees mentioned seeing bats in their sleeping bays on multiple nights while trainees were asleep. Based on recommendations

from the Advisory Committee on Immunization Practices (1) and with the consensus of military and civilian experts, it was determined that the 45 trainees currently living in the affected dormitory would require rabies PEP. Trainees in this “index flight” received their first dose of vaccine that evening and received human rabies immune globulin 3 days later, after sufficient local supply was established.

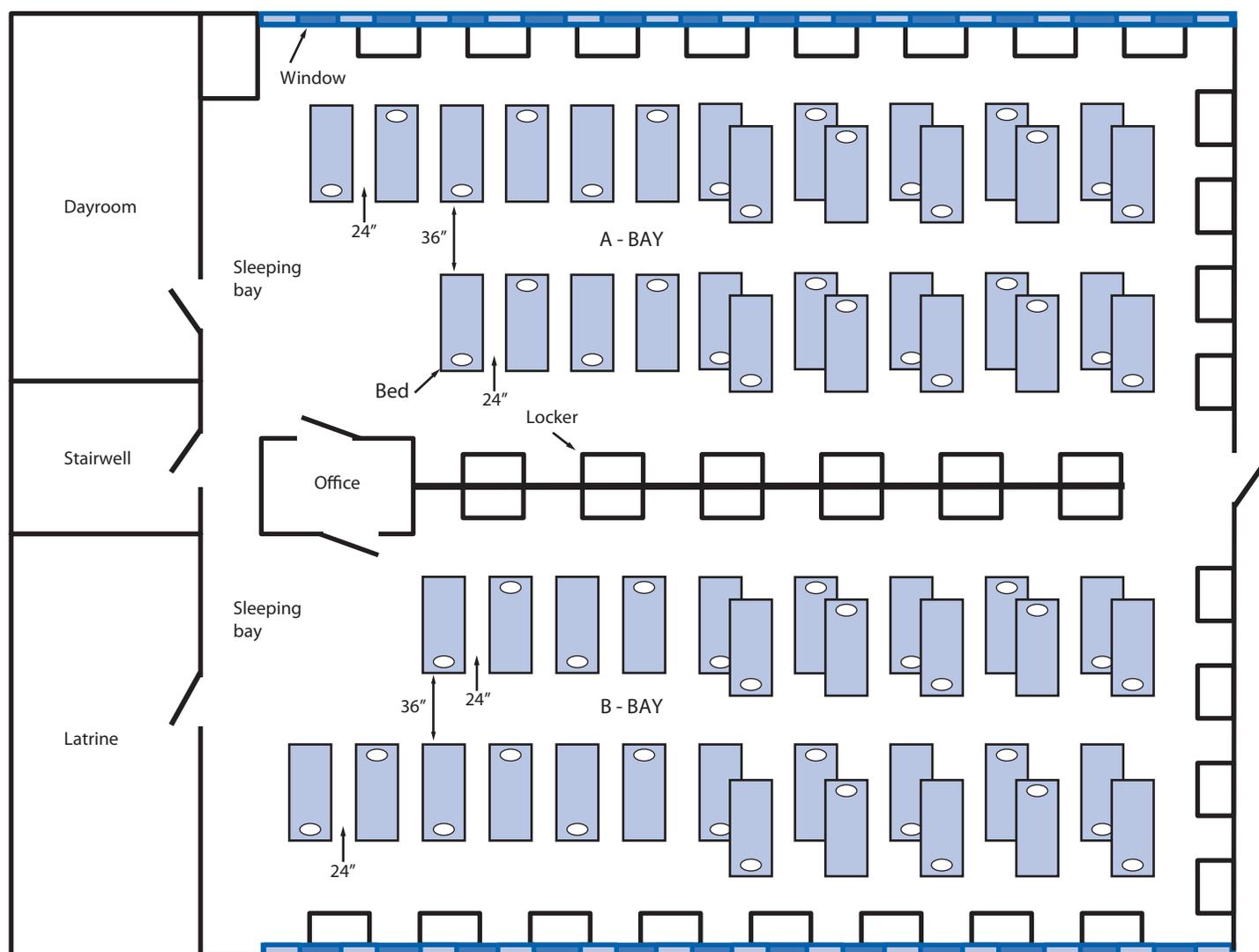
Later on January 17, the investigative team determined that bats might have been seen in six additional dormitories within the same building. Applying ACIP recommendations (1) and drawing on the experience of mass bat exposure investigations by the Kentucky Department for Public Health (5) and the Kansas Department of Health and Environment (6), the team interviewed 866 trainees to assess their exposure risk. Because trainees sleep in open bays, and thus would have similar exposures, flight-based risk category criteria were established in conjunction with CDC and the state health department (Table). Rabies PEP was recommended for all trainees in flights meeting criteria for increased risk (moderate risk or high risk).

Interviews determined that bats had been observed in seven of the building's 20 dormitories at various times during December 22–January 16. The majority of exposures were reported by trainees in the index flight in the week preceding the investigation (January 10–16), and this flight was considered at high risk. Three additional flights were found to be at moderate risk, and the remaining 14 flights were determined to be at low risk; two other dormitories were not occupied.

Individualized risk assessments were performed on trainees who had previously moved out of the building. Of 35 trainees who might have been exposed but were not currently residing in the building (19 had been moved to medical hold, 15 had separated from training, and one had been hospitalized for an unrelated condition), it was determined that nine were at increased risk and required PEP. Three of these nine trainees reported direct contact with a bat, but none reported a bite.

Rabies PEP was initiated on January 20 for 157 trainees not in the index flight who were found to be at increased risk for exposure. For two trainees, the series was discontinued after the first dose when the two were reclassified as at low risk in accordance with the criteria established (another trainee, with documented previous receipt of rabies preexposure prophylaxis,

FIGURE. Floor plan of a dormitory housing one flight\* of U.S. Air Force basic trainees — Joint Base San Antonio (JBSA)-Lackland, Texas, January 2014



\* A flight is the smallest organizational unit in the U.S. Air Force. At Lackland there were 50 trainees in each flight, occupying two sleeping bays of each dormitory.

received 2 vaccine doses and no human rabies immune globulin). In all, 200 trainees (45 in the index flight plus 155 of 157 not in the index flight) completed the rabies PEP series during January 20–February 3. PEP was not indicated for any of the instructors.

Adverse reactions included urticaria (two cases) and pruritus (six), which approximate the respective incidence rates of 1.6% and 3.3% previously reported (7). Symptoms began within 15 minutes of vaccine administration for all persons; there were no reactions to human rabies immune globulin alone. Of those with urticarial reactions, one had rapid resolution with oral diphenhydramine, and the other required intramuscular methylprednisolone and intramuscular diphenhydramine. The latter person experienced a more intense reaction after the second vaccination and was treated with an oral steroid taper and

H2 blocker to complete the series. The remaining six persons had mild reactions that resolved with oral diphenhydramine.

Although the dates of the bat sightings were well confirmed, the team extended the investigation retrospectively 1 year given the prolonged incubation period for rabies (1). After interviewing 56 training instructors in the squadron and reviewing all pest control requests made to civil engineering in the past year, no previous exposures were identified. One Mexican free-tailed bat captured during the investigation tested negative for rabies.

The investigative team facilitated ongoing and direct communication with the trainees, training leaders, and local media to describe rabies transmission risk, rationale for PEP, and expectations for injections. Trainees were allowed to telephone a family member to describe the situation.

## Bat Infestation and Remediation

The installation's civil engineering unit was notified of the bat sightings early in the investigation. Working with a commercial bat control specialist, they determined, based on guano, urine, and grease markings, that a small colony of bats (estimated at 400–600) had been nesting inside wall crevices of the building for several years. Although it is unclear why they only recently entered the dormitories, it was speculated that an unseasonably warm period halted the typical southward migration of bats from southern Texas. The return of cold temperatures caused the bats to seek warmth, and they entered the dormitories through porous structures.

Building remediation took several days, during which time trainees in the affected dormitories were relocated. The commercial bat control specialist completed the risk assessment, and civil engineers sealed gaps where bats could gain entrance to the sleeping quarters. Air vents were covered with a fine wire mesh, fastened with sheet metal, and sealed with metal tape. Damaged ceiling tiles were replaced and fastened with metal tape. Fissures in walls or between floor materials were caulked or covered with foam and sealed with metal tape. Windows with inefficient locking mechanisms were secured. One-way exclusion devices were installed to allow any remaining bats to leave but not return. A postremediation inspection verified proper sealing of entry points, and after 2 weeks of daily inspections for bat sightings, the exclusion devices were removed and the building was declared clear for reoccupation. The other occupied older buildings were inspected and considered free of bats.

### Discussion

This is the largest military investigation of rabies exposure, both in terms of the number of persons interviewed for potential exposure (922) and the number who received rabies PEP (200), with an associated cost of approximately \$400,000. Careful adherence to current building codes likely is more than adequate to prevent bat infestations in new buildings. For older structures, which might have been built under less stringent codes and have become porous over time, routine inspections by animal control specialists for bat and other animal infestations are recommended.

Rabies is a zoonotic disease that causes an acute encephalomyelitis and is almost always fatal if PEP is not administered before symptom onset. PEP is recommended for persons who are bitten or scratched by a bat and that bat is either unavailable for testing or tests positive for rabies. It is also recommended for persons who might have had an exposure they are unaware of (e.g., waking in a room with a bat or being near a bat while

**TABLE. Flight-level\* risk category criteria used in an assessment of rabies exposure risk among U.S. Air Force basic trainees — Joint Base San Antonio (JBSA)-Lackland, Texas, January 2014**

Risk category	Category criteria
High	Vast majority (>75%) of the flight woke up to find one or more bats in the sleeping bay <i>and</i> this occurred on $\geq 2$ nights <i>and</i> interviews were totally corroborative.
Moderate	A proportion (1%–75%) of the flight woke up to find one or more bats in the sleeping bay <i>and</i> this occurred on $\geq 1$ night <i>and</i> interviews were mostly corroborative.
Low	No one in the flight woke up to find a bat in the sleeping bay <i>and</i> interviews were totally corroborative; <i>or</i> a proportion of the flight originally reported waking up to find a bat in the sleeping bay, but upon further questioning it was concluded that the bat was observed for the entire time it was in the bay.

\* A flight is the smallest organizational unit in the U.S. Air Force. At Lackland there were 50 trainees in each flight, occupying two sleeping bays of a dormitory.

having a condition that might result in a lack of awareness of a bat bite) (1). Military trainees, who have multiple reasons for altered sleep, might be at increased risk for an undetected bat bite while sleeping.

The discovery of bats in the training building was made by health personnel responding to an unrelated concern. Despite numerous bat sightings involving multiple trainees and instructors over several days, no one had reported them to public health authorities. This supports previous reports that document an underappreciation of the health risks associated with indoor bat exposures (5). The degree of risk was conveyed at subsequent meetings with military leaders and to all incoming trainees. No known rabies infections have ever been acquired during U.S. Air Force basic training. The death of a recent Lackland graduate in 2011 was attributed to raccoon-variant rabies not found in Texas; the trainee likely was infected while animal trapping in North Carolina before enlisting in the military (8).

This investigation benefited from early and consistent collaboration with logistics, civil engineering, and training leadership staff members, and from consultation with various military and civilian experts. Risk assessments of previous mass bat exposures (5,6) were used to guide the response. Because at least four such mass exposure episodes have been reported since 2010 (5,6,9), it might be beneficial to have a formal, national guideline outlining the appropriate strategy in these situations. Risk assessments and decisions regarding rabies PEP should be conducted in consultation with appropriate public health or preventive medicine authorities.

**What is already known on this topic?**

Human rabies infections in the United States, although rare, typically result from contact with a bat. Exposures to bats while sleeping comprise a large percentage of these cases. Occasionally these exposures happen on a massive scale, such as when bats are found in large, shared sleeping quarters.

**What is added by this report?**

A total of 922 U.S. Air Force basic trainees and training instructors were interviewed for potential exposure to bats, and 200 trainees received rabies postexposure prophylaxis (PEP). Given the shared exposure status of trainees sleeping in common bays during basic training, this investigation relied on group-based, rather than individual-based, risk assessments, using a questionnaire developed in collaboration with CDC and state authorities.

**What are the implications for public health practice?**

Older buildings might be susceptible to bat infestations. Periodic environmental assessment and bat remediation can prevent exposure of persons to bats and decrease the need for rabies PEP. Exposure risk assessment and decisions regarding PEP should be conducted in consultation with appropriate public health or preventive medicine authorities.

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## Update on Cases of Delayed Hemolysis After Parenteral Artesunate Therapy for Malaria — United States, 2008 and 2013

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Parenteral artesunate, a first-line treatment for severe malaria in several countries, is associated with increased survival and has a better safety profile compared with parenteral quinine or quinidine (1,2). However, parenteral artesunate has been associated with delayed hemolysis, leading to concerns about drug toxicity. Postartemisinin delayed hemolysis (PADH) can occur 1–3 weeks after initiation of treatment with artemisinin-based antimalarials such as artesunate and is characterized by a decline in hemoglobin levels amid hemolysis. CDC conducted a literature review and identified 18 cases of PADH since 2012, mostly in European travelers. In addition, malaria case reports were reviewed retrospectively, and active surveillance was implemented in the United States, identifying two additional PADH cases, for a total of 20. A few patients with PADH required blood transfusions, but among patients where complete follow-up information was available, all made a full recovery. Results from this review suggest that PADH occurs because of delayed clearance of once-infected erythrocytes, probably as a result of a pharmacologic effect of parenteral artesunate and not drug-related toxicity. Therefore, parenteral artesunate can still be considered a safe treatment for severe malaria and should remain an option for its treatment.

Malaria, a mosquito-borne disease caused by *Plasmodium* spp., was eliminated from the United States in the 1950s. Since 1971, about 1,500 cases per year have been reported in the United States, almost all imported by travelers who went to malaria-endemic areas (3). In the United States, several antimalarials are available for treatment of uncomplicated malaria, including atovaquone-proguanil, artemether-lumefantrine, chloroquine, oral quinine plus doxycycline (or tetracycline or clindamycin), and mefloquine, depending on species and expected sensitivity.

Antimalarial options for treatment of severe malaria, however, are limited. The CDC-recommended treatment, parenteral quinidine (given with a second drug: doxycycline, tetracycline, or clindamycin), is the only Federal Drug Administration (FDA)-approved parenteral antimalarial regimen currently available in the United States. Until 1985, parenteral quinine was the only option for treatment of severe malaria even though it was not available commercially and had to be obtained through CDC. In 1991, a data review resulted in the new recommendation of parenteral quinidine as first-line treatment, and parenteral quinine became no longer accessible through

CDC (4). Since 2007, parenteral artesunate has been available for treatment of severe malaria in the United States through an investigational new drug (IND) protocol with FDA (5). Currently, parenteral artesunate is only released by CDC when parenteral quinidine is contraindicated, not tolerated, or not available. Treatment of severe malaria with parenteral artesunate is associated with increased survival and fewer side effects compared with treatment with parenteral quinine or quinidine (1,2). However, delayed hemolysis has been reported in association with parenteral artesunate therapy of malaria (6–8).

In PADH, hemoglobin levels decline as a result of hemolysis 1–3 weeks following initiation of treatment of malaria with a drug in the artemisinin class of antimalarials (e.g., artesunate) (6,8). No deaths have been attributed to PADH, but levels of hemoglobin as low as 2.8 g/dL (normal ranges = men, 14.0–17.0 g/dL; women, 12.5–15.0 g/dL; and children, 10.3–16.0 g/dL) have been reported, and patients have required blood transfusions (6,7). No demographic risk factors for PADH have been identified. Multiple case definitions for PADH have been suggested, resulting in a wide range of incidence rates.

A literature review conducted in 2012 identified 19 PADH cases during 2010–2012, the majority occurring in European travelers returning from countries where malaria is endemic (6). To update this literature review, CDC conducted a search via the National Library of Medicine's PubMed and identified 18 additional PADH cases. Keywords used included "artesunate" combined with "delayed hemolysis" and "hemolytic anemia." Five of the 18 cases were reported in children from Gabon and Ghana, with nadir hemoglobin levels ranging from 2.8 g/dL to 8.5 g/dL, and a peak lactate dehydrogenase (LDH) value ranging from 400 U/L to 1,400 U/L (normal = 125–240 U/L) (7). In one published report, a surveillance study of returned travelers in France, 13 PADH cases were reported, with a decline of 12% in mean hemoglobin levels amid increased hemolytic activity 7–14 days after treatment initiation with artesunate (8).

As a result of the findings from the 2012 literature review, the CDC artesunate IND protocol was amended in 2012 to encourage active surveillance for PADH. As a result, for the first time since initiation of the IND protocol in 2007, two new cases in the United States, among 244 artesunate treatments administered by CDC up to August 2014, were detected

by CDC. One case, occurring in 2008, was detected through a retrospective record review; the second case, occurring in 2013, was detected prospectively through active surveillance. Therefore, since the 2012 literature review (6), a total of 20 additional PADH cases have been identified, 18 cases in the literature and two cases in the United States, which are described as follows.

### Case Reports

**Patient A.** In November 2008, a woman aged 49 years was diagnosed with severe falciparum malaria with 9% infected red blood cells, which is hyperparasitemia (defined as parasitemia >5%). She was successfully treated with parenteral artesunate and discharged from the hospital 4 days after admission. Her hemoglobin level was 11.1 g/dL at the time of admission and declined to 8.2 g/dL at the time of discharge. Eleven days after treatment initiation, the patient reported weakness, fatigue, shortness of breath, and bilateral lower extremity edema. On that date, her hemoglobin level was 5.7 g/dL; other laboratory test results included LDH 981 U/L, total bilirubin 1.2 mg/dL (normal = 0.1–0.9 mg/dL), and reticulocyte count 12.3% (normal = 0.5–1.5%). No other hematologic evaluation was done. She was given 3 units of packed red blood cells; her hemoglobin level subsequently rose to 9.8 g/dL 19 days after she first received artesunate. One week after the transfusion, the patient reported resolution of both shortness of breath and edema.

**Patient B.** In August 2013, a man aged 26 years went to an outpatient clinic with a febrile illness that was presumptively treated as malaria. He received 2 doses of artemether-lumefantrine as an outpatient, but developed progressive confusion and went to the emergency department on the next day. That same day, he was admitted and diagnosed with severe falciparum malaria with >10% parasitemia; parenteral artesunate treatment was initiated. His hemoglobin level on admission was 8.9 g/dL, and he was transfused with 3 units of packed red blood cells during the first 4 days of hospitalization. After the standard 3-day course of atovaquone-proguanil following artesunate therapy, his treatment with atovaquone-proguanil was extended to 8 days, longer than recommended by CDC's malaria treatment guidelines and the artesunate IND protocol (9). His hemoglobin levels stabilized at 8.5 g/dL for several days. However, 9 days after treatment initiation with artesunate, his hemoglobin level dropped to 6.8 g/dL, and his total bilirubin rose to 3.4 mg/dL. Additional laboratory tests were consistent with acute hemolytic anemia: haptoglobin <0.1 g/L (normal = 0.2–2.0 g/L), LDH 5,882 U/L, and reticulocyte count 3.8%. The patient received 4 additional units of packed red blood cells and was discharged 13 days after parenteral artesunate initiation.

### Discussion

PADH can be a clinically relevant side effect after parenteral artesunate treatment. Follow-up visits up to 1 month following treatment with parenteral artesunate are recommended to detect and manage this condition. According to a proposed case definition, PADH is a nonrecurring event characterized by a 10% or greater decrease in hemoglobin levels in the setting of a haptoglobin level <0.1 g/L and an increase of LDH levels to >390 U/L, or an increase of  $\geq 10\%$  over baseline at least 7 days after initiation of parenteral artesunate treatment (10). Applying this case definition could help to improve specificity of PADH diagnoses. For example, considering the 19 cases from the 2012 literature review, the 18 identified by the recent literature review since then, and the two U. S. cases reported (39 cases in total), 23 had sufficient information and met the proposed case definition, one could be excluded from a PADH diagnosis, and 15 had insufficient information to assess exclusion, and should be considered as likely PADH cases (6–8).

Because all previously reported cases were treated with parenteral artesunate produced by facilities not accredited for good manufacturing practice (GMP) standards, direct toxicity resulting from treatment with non-GMP parenteral artesunate had been hypothesized as a PADH cause (6). The recent occurrence of two PADH cases in the United States, where only GMP-assured artesunate is used, conflicts with this hypothesis. A recently published report observed that PADH is more likely to occur in patients with high parasitemia (8). In contrast to treatment with quinine, which does result in immediate destruction of infected erythrocytes, artesunate kills malaria parasites, which are then selectively removed from erythrocytes by the spleen without immediate erythrocyte destruction. Following completion of artesunate treatment, these once-infected erythrocytes continue to circulate, but with a reduced life span. Once-infected erythrocytes are removed by the spleen at the end of their lifespan, 1–3 weeks. This event happens rather synchronously, and a substantial increase in hemolysis occurs, with the resultant decrease in hemoglobin levels (7,8). The report of 60 French returned travelers from countries where malaria is endemic found that the 13 with PADH had higher concentrations of once-infected erythrocytes compared with those diagnosed with non-PADH anemia 1 week after parenteral artesunate treatment initiation. In addition, higher parasitemia was associated with higher concentrations of once-infected erythrocytes, and the level of once-infected erythrocytes was a strong predictor of PADH (8).

Flow cytometry, which is available at most modern hospitals, can be adapted to estimate once-infected erythrocyte levels. The development of such a point-of-care test that can identify patients at risk for PADH with a high sensitivity and

**What is already known on this topic?**

Parenteral artesunate, an artemisinin that is a first-line treatment for severe malaria in many countries, is associated with increased survival and has a better safety profile than the parenteral alternatives, quinine and quinidine. However, post-artemisinin delayed hemolysis (PADH) can occur 1–3 weeks after initiation of malaria treatment with drugs in the artemisinin class of antimalarials, resulting in anemia. The incidence of PADH is not precisely known.

**What is added by this report?**

In addition to 18 new PADH cases identified through a literature review, one U.S. case was identified through retrospective review and one through active surveillance, for a total of 20 new PADH cases. It is unlikely that the two U.S. PADH cases, in patients treated with artesunate meeting good manufacturing practices, resulted from drug toxicity related to manufacturing practices. Instead, hemolysis probably resulted from delayed clearance of once-infected erythrocytes, which continue to circulate after artesunate has killed the parasites.

**What are the implications for public health practice?**

Parenteral artesunate is a safe treatment for severe malaria.

specificity would be useful in identifying those patients who would benefit from more stringent follow-up (8). Until the development and implementation of such a point-of-care test, all patients treated with parenteral artesunate should continue to be followed up for 1 month after treatment.

PADH likely is the result of the delayed clearance of once-infected erythrocytes, which continue to circulate after the pharmacologic effect of parenteral artesunate, and is not the result of any toxic effect of parenteral artesunate. Therefore, parenteral artesunate is still considered safe and can remain as the first-line treatment for severe malaria in countries where it is licensed for use. Parenteral artesunate in the United States is available to qualifying patients by contacting CDC.\*

\* At telephone 770-488-7788, Monday through Friday, from 9 a.m. to 5 p.m., or at 770-488-7100, after hours.

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## Assessing and Mitigating the Risks for Polio Outbreaks in Polio-Free Countries — Africa, 2013–2014

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Since 1988, when the Global Polio Eradication Initiative (GPEI)\* began, the annual number of polio cases has decreased by >99% (1). Only three countries remain that have never interrupted wild poliovirus (WPV) transmission: Afghanistan, Nigeria, and Pakistan (1). Since 2001, outbreaks have occurred in 31 formerly polio-free countries in Africa, with outbreaks in 25 countries caused by WPV originating in Nigeria (2–4). After the declaration of the World Health Assembly of polio eradication as a programmatic emergency in 2012, efforts to identify areas at high risk for importation-associated outbreaks and to reduce that risk have been intensified (5). This report updates the 2013 assessment of the risk for outbreaks attributable to importation of poliovirus in 33 countries in Africa, using indicators of childhood susceptibility to poliovirus and proximity to countries currently affected by polio (6). From January 2013 to August 12, 2014, outbreaks occurred in five African countries. Four of the five (Cameroon, Equatorial Guinea, Ethiopia, and Somalia) have had recent transmission (cases within the previous 12 months). Based on the current risk assessment, 15 countries are considered to be at high risk for WPV outbreaks, five at moderate-to-high risk, seven at moderate risk, and six at low risk. In 15 of the 33 countries, less than half of the population resides in areas where surveillance performance indicators have met minimum targets (7). Enhanced, coordinated activities to raise childhood immunity are underway in 2014 to prevent additional WPV spread. Although substantial progress toward polio eradication has occurred in Nigeria, all African countries remain at risk for outbreaks as long as WPV continues to circulate anywhere on the continent.

### Current Outbreaks

Two multicountry outbreaks have occurred in Africa during 2013–2014 because of WPV imported from Nigeria; both are ongoing (4). The first outbreak, confirmed in May 2013 in the Horn of Africa, currently totals 222 cases: Somalia (198), Kenya (14), and Ethiopia (10). The first identified case was in

a child in Somalia with onset in April 2013; subsequent cases were identified in eastern Kenya and in the Somali region of Ethiopia. Genomic sequence analysis of WPV isolates confirmed linkage of the cases and Nigeria as the source. The most recent cases were reported from the Puntland region of Somalia in June 2014. Transmission in Kenya appears to be interrupted, with onset of the latest case in July 2013; the latest case in Ethiopia had onset in January 2014.

A second outbreak in Central Africa (1), confirmed in October 2013, currently totals 14 cases: Cameroon (nine) and Equatorial Guinea (five). Genomic sequence analysis revealed that the outbreak virus originated in Nigeria and is most closely linked with a case in Chad in 2011, suggesting that this virus had been circulating undetected in the region for a substantial time before the first case was identified. The cases in Equatorial Guinea are linked to the Cameroon cases virologically and epidemiologically. The most recent case in Cameroon occurred in July 2014, and the most recent in Equatorial Guinea occurred in May 2014.

### Risk Assessment

In Nigeria, as of August 12, 2014, only five WPV cases have been reported in 2014, compared with 43 cases by the same date in 2013 and 83 cases by the same date in 2012. However, 25 African countries have experienced WPV importation outbreaks during 2009–2014. This analysis included those countries and eight selected neighboring countries. Childhood immunity indicators are derived from national coverage estimates for the third dose of oral poliovirus vaccine (OPV3) by age 12 months and the vaccination history of children aged 6–59 months who have been investigated for acute flaccid paralysis (AFP) with negative results for WPV. Reported values for each indicator are classified into risk tiers. Countries are considered to be at high risk for outbreaks if at least two of three of their immunity indicators fall in a high-risk tier (Table 1). Countries are considered to be at moderate-to-high risk for outbreaks if one of three childhood immunity indicators falls in a high-risk tier. Countries are considered to be at moderate risk for outbreaks if none of their population immunity risk criteria falls into a high-risk tier but one or more suggest moderate vulnerability. Countries are considered to be at low risk for outbreaks if all of their childhood immunity

\*The Global Polio Eradication Initiative is a public-private partnership led by national governments and led by the World Health Organization, Rotary International, CDC, and the United Nations Children's Fund (UNICEF). Additional information available at <http://www.polioeradication.org/aboutus.aspx#sthash.zicgwihb.dpuf>.

TABLE 1. Key risk indicators for 25 countries with wild poliovirus (WPV) cases during 2009–2014 and eight selected neighboring countries, by risk for transmission after an importation of WPV — Africa, 2014

Risk level/ Country	Childhood immunity indicators			Routine immunization indicators		Surveillance quality indicators			Other factors			
	Risk tier: routine immunization with OPV3 national coverage*†	Risk tier: vaccine history with ≥3 doses in children with NPAFP*§	Risk tier: vaccine history zero doses in children with NPAFP*¶	OPV3 national coverage (%)	% districts with ≥80% OPV3 coverage**	Risk tier for % provinces with ≥2 AFP cases per 100,000 children aged <15 yrs††	Risk tier for % of provinces with 80% of AFP stool specimen collection within 2 wks††	% of population residing in a province that meets both criteria	Areas of insecurity in the country that disrupt vaccine importations <sup>§§</sup>	No. of WPV importations 2009–2013	Outbreak response countries (OR) and other priority countries (PC)	Borders with a country with WPV case in the last 12 months¶¶
<b>High risk</b>												
Benin	High	High	High	69	84	Mod	Low	59	No	0	PC	Yes
Cameroon	Mod	High	High	89	78	Low	High	36	Yes	3	OR	Yes
CAR	High	Low	Low	23	4	High	Low	35	Yes	2	PC	Yes
Chad	High	Mod	Low	48	60	Low	Mod	73	Yes	4	PC	Yes
Congo	High	High	High	69	73	Low	Mod	79	No	1	PC	Yes
Djibouti	Mod	High	Low	82	50	Low	Low	100	No	0		Yes
Equatorial Guinea	High	High	Low	3	6	High	High	0	No	0	OR	Yes
Ethiopia	High	High	Mod	72	50	Low	High	21	No	1	OR	Yes
Gabon	High	Low	Low	79	33	Low	High	0	No	1	PC	Yes
Guinea	High	High	Low	63	92	Low	Mod	38	No	2		No
Kenya	High	Low	Low	76	45	Low	Low	91	No	3		Yes
Niger	High	Low	Low	70	90	High	High	0	Yes	11	PC	Yes
Somalia	High	High	High	42	6	Low	High	99	Yes	1	OR	Yes
South Sudan	High	Low	Low	45	23	High	Low	19	Yes	0		Yes
Uganda	High	High	Mod	78	83	Mod	Mod	46	No	0		No
<b>Moderate-to-high risk</b>												
Angola	Low	High	Low	93	66	Mod	Low	46	No	1	PC	No
Cote d'Ivoire	Mod	High	Low	88	99	Low	Mod	16	No	2	PC	No
DRC	High	Mod	Low	72	80	Low	Low	90	Yes	3	PC	No
Liberia	Mod	High	Low	89	87	Mod	Low	23	No	2		No
Mali	High	Low	Low	74	77	Low	Low	96	Yes	6	PC	No
<b>Moderate risk</b>												
Burkina Faso	Mod	Low	Low	88	100	Low	Low	95	No	1		No
Eritrea	Low	Low	Low	94	40	Mod	Low	65	No	1		Yes
Guinea-Bissau	Mod	Low	Low	80	91	Low	High	0	No	0		No
Mauritania	Mod	Low	Low	80	42	Low	Mod	61	No	1		No
Senegal	Low	Mod	Mod	92	32	Mod	Mod	54	No	3		No
Sudan	Low	Low	Low	93	93	Low	Low	100	Yes	0		Yes
Togo	Mod	Low	Low	84	95	Low	Low	58	No	2		No
<b>Low risk</b>												
Burundi	Low	Low	Low	96	93	High	Low	38	No	1		No
Gambia	Low	Low	Low	97	100	Low	Mod	67	No	0		No
Ghana	Low	Low	Low	90	75	High	Low	34	No	0		No
Rwanda	Low	Low	Low	98	100	Low	Low	100	No	0		No
Sierra Leone	Low	Low	Low	92	93	Mod	Low	79	No	1		No
Tanzania	Low	Low	Low	91	79	Mod	Low	66	No	0		No

**Abbreviations:** OPV3 = third dose of oral poliovirus vaccine; NPAFP = nonpolio acute flaccid paralysis; AFP = acute flaccid paralysis; CAR = Central African Republic; DRC = Democratic Republic of the Congo.

\* Countries were considered to be at low risk at ≥90%, moderate risk at 80%–89%, and high risk at <80%.

† OPV3 coverage is based on World Health Organization (WHO)/United Nations Children's Fund (UNICEF) estimates of the national vaccination coverage of the third dose of diphtheria-tetanus-pertussis (DTP3) for 2013.

§ Nonpolio acute flaccid paralysis database maintained by WHO.

¶ Countries were considered to be at low risk at <5%, moderate risk at 5%–10%, and high risk at >10%.

\*\* Routine immunization administrative data as reported via WHO-UNICEF Joint Reporting Form, 2013, are based on use of DTP3 as proxy for OPV3 that does not count OPV doses administered during supplementary immunization activities.

†† Countries were considered to be at low risk at ≥80%, moderate risk at 50%–79%, and high risk at <50%.

§§ Areas with limitations in access and/or threats to the physical security of vaccination staff members.

¶¶ Nigeria, Cameroon, Ethiopia, Somalia, and Equatorial Guinea.

risk criteria suggest low vulnerability. The risk category for a country was increased one level if it shared a border with any country with recent transmission; this adjustment resulted in raising seven countries from the moderate-to-high-risk to the high-risk category and two countries from the low to the moderate risk category.

Other factors are taken into account when planning activities to mitigate risk for outbreaks after importation (Table 1). Surveillance performance indicators reflect the ability to detect cases quickly and thus limit spread of the virus. Country insecurity can disrupt routine immunization programs resulting in pockets of underimmunized children. The number of poliovirus importations for each country in the last 5 years reflects exposure history.

## Risk Mitigation Activities

**Immunization activities.** Periodic preventive supplementary immunization activities (SIAs) take place nationally (national immunization days [NIDs]) and subnationally (subnational immunization days [SNIDs]) in polio-free countries, based on subnational immunization performance (Figure) to boost childhood immunity and limit vulnerability after WPV importation.

Of the 20 high-risk and moderate-to-high-risk countries, 17 implemented at least one SIA in 2012, and 18 implemented at least one SIA in 2013 (Table 2). During 2012, NIDs were conducted in seven of 15 high-risk countries and all five moderate-to-high risk countries; SNIDs were conducted in nine and four countries, respectively (Table 2). During 2013, NIDs were conducted in 11 of the high-risk countries and all five of the moderate-to-high risk countries. None of the five African countries with outbreaks in 2013 and 2014 had conducted nationwide polio SIAs in 2012, and none were planned in 2013 until after the first case in the countries was discovered. In 2014, every moderate-to-high and high-risk country is scheduled to have at least two nationwide campaigns, except for Angola, the Democratic Republic of the Congo, and Uganda.

**Strengthening surveillance.** Strengthening AFP surveillance to promptly detect possible imported cases will speed response and limit the spread of WPV. The first major surveillance indicator is the rate of nonpolio acute flaccid paralysis (NPAFP) cases detected among children aged <15 years (the “NPAFP rate”). The target NPAFP rate is two or more cases per 100,000 children aged <15 years. A second major indicator, specimen adequacy, is the proportion of AFP cases for which two stool specimens were collected within 14 days of paralysis onset,  $\geq 24$  hours apart, arriving in good condition at an accredited laboratory. The target for stool specimen adequacy is  $\geq 80\%$ . Both indicators are analyzed at the national and provincial/state level (8).

Nine of the 15 high-risk countries had  $\geq 80\%$  of provinces with an NPAFP rate of two or more cases per 100,000 children aged <15 years (Table 1). Only six of the high-risk countries met the standard of having  $\geq 80\%$  of provinces meeting the target of  $\geq 80\%$  adequate stool specimens. In only six of the 15 high-risk countries was more than half of the population living in an area meeting both surveillance indicators. Two of the five moderate-to-high-risk countries had more than half of their population in areas meeting both surveillance indicators. Six of the seven moderate-risk and four of the six low risk countries had more than half of their population in areas meeting both surveillance indicators.

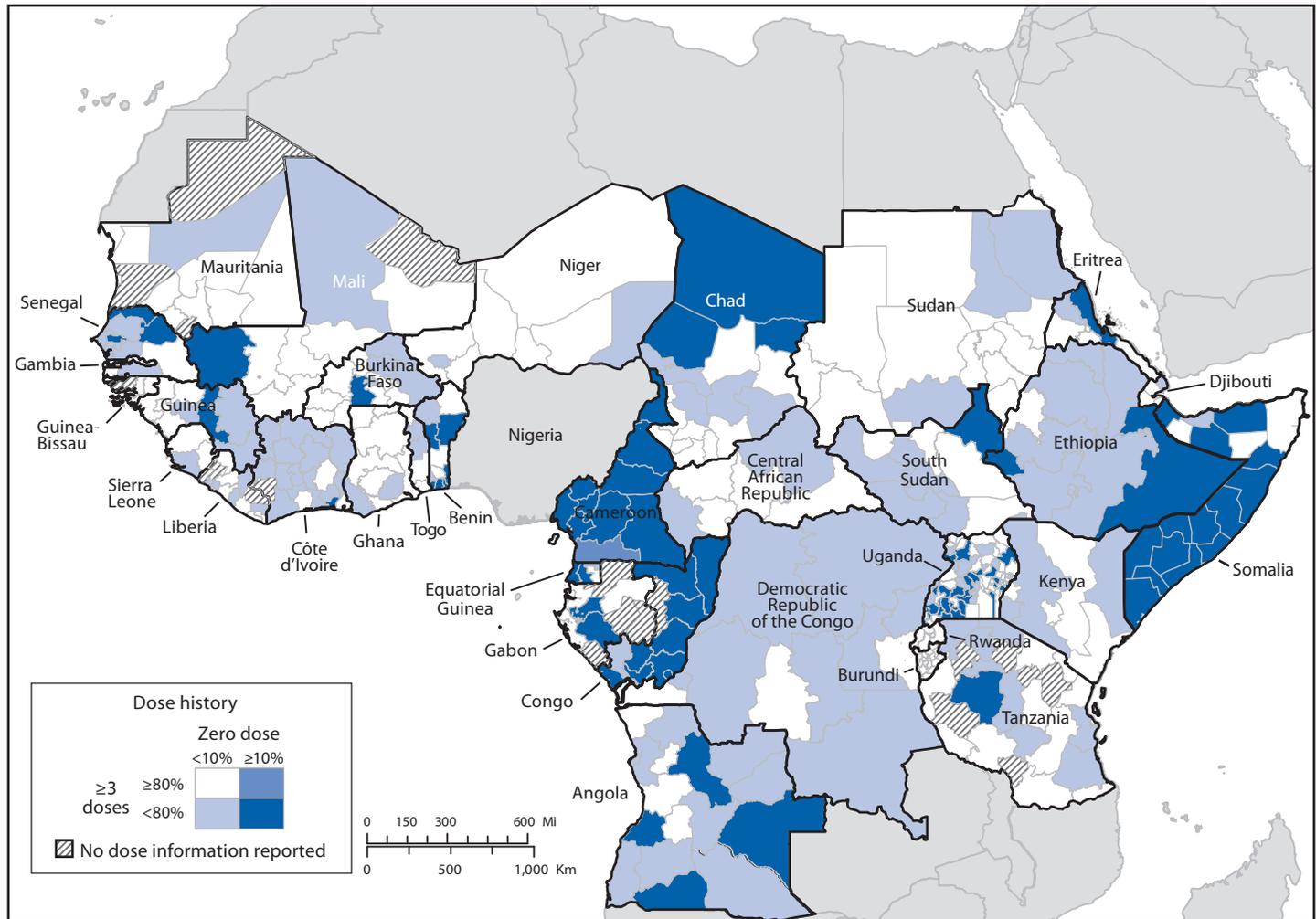
World Health Organization (WHO) regional offices and other GPEI partners conduct periodic activities to improve program performance and strengthen AFP surveillance. These include program assessments, AFP surveillance reviews, and surveillance training at national and subnational levels (Table 2). These activities are in addition to the development and testing of national emergency polio preparedness plans as recommended by the WHO African and Eastern Mediterranean regional certification commissions.

## Discussion

African countries continue to be at risk for WPV outbreaks, as proven by the two multicountry outbreaks during 2013–2014. Low immunity levels of children caused by chronic weaknesses in the delivery of immunization services puts countries at risk for continued spread of WPV after importation. Insecurity is a key factor in preventing children’s access to vaccines in Africa, including the complex humanitarian emergencies in Central African Republic, South Sudan, and Somalia. However, insecurity was not a factor in outbreaks in Cameroon and Equatorial Guinea.

GPEI partners recently formalized the way that risk assessments are conducted to better inform the planning of the international polio SIA calendar and provision of technical assistance. The current GPEI process of assessing risks in polio-affected WHO regions uses a consensus of the different approaches used by CDC, WHO, and the Institute for Disease Modeling based on the polio vaccination dose history of children with NPAFP as well as other factors. The review of country risk profiles in May 2014 was used by GPEI partners to plan the vaccination schedule for the second half of 2014, substantially increasing the number of planned campaigns in polio-free countries, and to plan focused technical assistance to enhance SIA effectiveness. The CDC-WHO risk tier approach presented in this report has essentially the same outcome as the formal, multi-agency approach conducted by GPEI partners in assessing susceptible children and is similar to the

FIGURE. Oral poliovirus vaccine dose history among children aged 6–59 months with nonpolio acute flaccid paralysis in countries experiencing importations of wild poliovirus during 2009–2013 and selected neighboring countries — Africa, July 2013–June 2014



risk assessments conducted by WHO regional offices to set priorities for SIAs within regions and countries.

SIAs, by delivering large numbers of vaccinations in a short time, are the most effective way of rapidly boosting a population's immune profile preventively or in response to an outbreak, especially where routine immunization of children is suboptimal. SIAs cannot fully correct for underlying problems in a country's routine immunization program. Without recent WPV cases, many polio-free countries do not have recent experience in conducting national campaigns, and the campaigns suffer in quality. After the recent outbreaks, the quality of many of the initial SIAs in Africa was noted to be poor because of inadequate planning, supervision, and coordination (9). The effectiveness of SIAs can be improved by holding coordination workshops among Ministry of Health staff, community leaders, and local partners to develop "micro plans," which are detailed implementation and local work plans that define the logistical needs, training, and

supervision needed to conduct quality vaccination campaigns and identify repeatedly missed subpopulations.

The findings in this report are subject to at least four limitations. First, national coverage estimates are subject to overestimation. Second, annual NPAFP data for smaller countries can fluctuate substantially. Third, recall of dose histories might be inaccurate. Finally, surveillance might be limited or biased by imprecise population estimates.

In May 2014, in a coordinated international effort to reduce international exportation of WPV, WHO declared the recent international spread of WPV a public health emergency of international concern (10) and issued temporary recommendations under the International Health Regulations (IHR 2005). These recommendations include 1) ensuring that residents and long-term visitors, including adults, traveling from Cameroon, Equatorial Guinea, Pakistan, and Syria receive vaccination before international travel; 2) encouraging

**TABLE 2. Risk mitigation activities for 25 countries with wild poliovirus (WPV) cases during 2009–2014 and eight selected neighboring countries, by risk for transmission after an importation of WPV — Africa, 2012–2014**

Risk level/Country	Supplementary immunization activities: National and subnational immunization days (NID/SNID)				Surveillance strengthening activities: national program assessments (PA),* surveillance reviews (SR), or surveillance training activities (ST)	
	Jan 2012–Dec 2012 (NID/SNID)	Jan 2013–Dec 2013 (NID/SNID)	Jan 2014–Jun 2014 (NID/SNID)	Jul 2014–Dec 2014 (NID/SNID) (Planned)	Jan 2013–Jun 2014	Jul 2014–Dec 2014 (Planned)
	<b>High risk†</b>					
Benin	3/0	4/0	2/0	1/0	SR	
Cameroon	0/4	2/4	6/0	3/2	PA, ST	PA, ST
CAR	5/2	0/4	1/1	2/2		PA
Chad	3/10	4/8	2/1	1/3	SR, ST	PA
Congo	0/0	2/0	1/0	3/0		
Djibouti	1/0	3/0	0/1	2/0		
Equatorial Guinea	0/0	0/0	3/1	4/0		ST
Ethiopia	0/3	2/8	0/4	2/2	PA, ST	PA, ST
Gabon	0/0	0/0	1/0	3/0		ST
Guinea	4/1	3/0	0/0	2/0	SR	
Kenya	0/6	1/8	3/3	0/2	PA, SR, ST	PA, SR, ST
Niger	4/4	5/3	2/1	2/1	SR, PA	ST
Somalia	0/4	7/17	3/9	3/4	PA, ST	PA, ST
South Sudan	4/1	4/2	2/0	2/0		ST
Uganda	0/2	0/2	0/1	1/1		PA, SR
<b>Total at high risk</b>	<b>24/37</b>	<b>37/56</b>	<b>26/22</b>	<b>31/15</b>		
<b>Moderate-to-high risk</b>						
Angola	3/1	3/0	0/0	1/1		
Cote d'Ivoire	4/0	3/0	1/0	2/0	SR	
DRC	2/8	2/3	0/3	1/2	SR, ST	SR
Liberia	3/1	3/0	0/0	2/0	PA	
Mali	1/6	4/2	2/0	1/1	SR	
<b>Total at moderate-to-high risk</b>	<b>13/16</b>	<b>15/5</b>	<b>3/3</b>	<b>7/4</b>		
<b>Moderate risk</b>						
Burkina Faso	4/1	4/1	2/0	2/0	SR	
Eritrea	0/0	2/0	0/0	0/0		ST
Guinea-Bissau	1/0	2/0	0/0	2/0	SR	
Mauritania	3/0	2/0	0/0	2/0	SR	
Senegal	1/0	2/0	0/0	2/0	SR	
Sudan	3/1	2/2	1/1	1/0		
Togo	1/0	2/0	0/0	2/0		
<b>Total at moderate risk</b>	<b>13/2</b>	<b>16/3</b>	<b>3/1</b>	<b>11/0</b>		
<b>Low risk</b>						
Burundi	0/0	0/0	0/0	0/0		
Gambia	1/0	2/0	0/0	2/0		
Ghana	1/0	2/0	0/0	2/0	SR	
Rwanda	0/2	0/0	0/0	0/0		
Sierra Leone	2/1	4/0	0/0	2/0		
Tanzania	0/0	0/0	0/0	0/0		
<b>Total at low risk</b>	<b>4/3</b>	<b>8/0</b>	<b>0/0</b>	<b>6/0</b>		

**Abbreviations:** CAR = Central African Republic; DRC = Democratic Republic of the Congo.

\* Program assessments include assessments conducted after the occurrence of a case of WPV infection or circulating vaccine-derived poliovirus infection and planned comprehensive immunization program reviews.

† Countries were considered to be at high risk for outbreaks in 2014 if two immunity indicators fell into a high-risk tier. Countries were considered to be at moderate-to-high risk for outbreaks if one of three immunity indicators fell into a high-risk tier. Countries were considered to be at moderate risk for outbreaks if any of the population immunity risk criteria suggested moderate vulnerability. A risk category for a country was increased one level if it shared a border with any country with recent transmission in the last 12 months.

residents and long-term visitors, including adults, traveling from Afghanistan, Ethiopia, Iraq, Israel, Somalia, and Nigeria to receive vaccination before international travel; and 3) ensuring that such travelers are provided an International Certificate of Vaccination documenting vaccination status.

The period for these recommendations was recently extended beyond August 3, 2014, with a reassessment to be conducted after 3 months.

The success of polio eradication efforts in Africa has led to a decrease in the number of countries with confirmed polio

**What is already known on this topic?**

Only three countries have never interrupted wild poliovirus (WPV) transmission: Afghanistan, Nigeria, and Pakistan. In 2012, the World Health Assembly declared polio eradication a programmatic emergency for public health.

**What is added by this report?**

Using indicators of childhood susceptibility to poliovirus and proximity to countries currently affected by polio, 15 of the 33 countries in Africa without polio transmission since January 2013 were assessed to be at high risk for WPV outbreaks, five at moderate-to-high risk, seven at moderate risk, and six at low risk. Based on risk assessments, coordinated activities to raise childhood immunity and improve surveillance for acute flaccid paralysis (AFP) are underway in 2014 to prevent additional WPV spread.

**What are the implications for public health practice?**

Although substantial progress toward polio eradication has occurred in Nigeria, all African countries remain at risk for WPV outbreaks as long as WPV circulation continues on the continent. Global partners need to continue to identify and analyze different risk factors so that the proper technical and logistic support can mitigate the risk for ongoing transmission after poliovirus importation. To reach eradication, governments at the national and subnational levels will need to remain politically committed, improve AFP surveillance, implement immunization activities as needed, and undertake other preparedness measures to lower risk.

cases, from 20 in 2009 to three in 2012. In 2013, that number jumped to six, with more than 80% of the cases found outside of Nigeria, the one country on the continent in which polio is endemic. The events of the past 18 months show that all countries on the continent remain at risk for WPV outbreaks as long as circulation continues in Africa. To stop current outbreaks, prevent additional spread, and interrupt indigenous transmission in Nigeria, concerted efforts are needed to raise

childhood immunity in the second half of 2014 and take the opportunity to interrupt all WPV transmission in Africa. Strengthening AFP surveillance in countries, regardless of a country's risk status, will help identify poliovirus importations quickly and limit spread of disease. To achieve eradication, governments at national and subnational levels will need to remain politically committed, implement immunization activities as needed, strengthen AFP surveillance, and undertake other preparedness measures to lower the risk for polio outbreaks.

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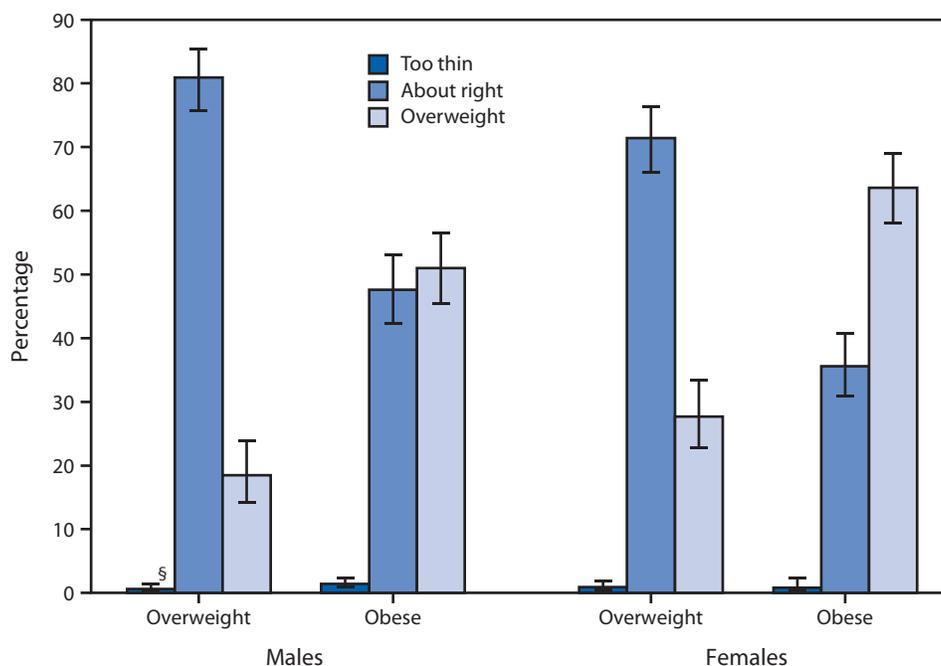
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## QuickStats

FROM THE NATIONAL CENTER FOR HEALTH STATISTICS

## Weight Perception\* Among Children and Adolescents Aged 8–15 Years, by Sex and Body Mass Index (BMI) Category† — National Health and Nutrition Examination Survey (NHANES), United States, 2005–2012



\* Based on responses to the question, "Do you consider yourself now to be: fat or overweight, too thin, or about the right weight?"

† Overweight is defined in children and adolescents as an age-specific and sex-specific BMI  $\geq$ 85th and <95th percentile of the 2000 CDC growth chart; obese is defined in children and adolescents as an age-specific and sex-specific body mass index  $\geq$ 95th percentile of the 2000 CDC growth chart.

§ 95% confidence interval

Overweight children and adolescents aged 8–15 years were more likely to report that their weight was "about right" than report that they were "overweight," according to NHANES data for the period 2005–2012. Among overweight females, 71.4% considered their weight "about right," and 27.7% thought they were "overweight." Among overweight males, 80.9% considered their weight "about right," and 18.5% thought they were "overweight." Among obese children and adolescents, 63.6% of females thought they were "overweight," and 35.6% considered their weight "about right"; the percentages of obese males who thought they were "overweight" (51.0%) was roughly equal to the percentage who considered their weight "about right" (47.6%).

**Source:** Sarafrazi N, Hughes JP, Borrud L, Burt V, Paulose-Ram R. Perception of weight status in U.S. children and adolescents aged 8–15 years, 2005–2012. NCHS data brief no. 158. Hyattsville, MD: US Department of Health and Human Services, CDC; 2014. Available at <http://www.cdc.gov/nchs/data/databriefs/db158.pdf>.

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