Postlicensure Safety Surveillance for Quadrivalent Human Papillomavirus Recombinant Vaccine

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On June 8, 2006, the Food and Drug Administration (FDA) licensed the quadrivalent human papillomavirus recombinant vaccine (qHPV) (Gardasil; Merck & Co, Inc, Whitehouse Station, New Jersey) for females aged 9 to 26 years to prevent infection with genital human papillomavirus (HPV) types 6, 11, 16, and 18.1 Later that month, the Advisory Committee on Immunization Practices (ACIP) recommended routine vaccination of females aged 11 to 12 years with 3 doses of qHPV and catch-up vaccination for females aged 13 to 26 years. Doses are administered intramuscularly on a schedule of 0, 2, and 6 months.2 The viruses HPV-16 and HPV-18 can cause cervical cancer, other anogenital cancers, and precancerous or dysplastic lesions and are responsible for about 70% of cervical cancers worldwide.3 The viruses HPV-6 and HPV-11 are the most common causes of genital warts.

Prior to licensure, clinical trials were conducted in more than 21 000 women. Vaccination with qHPV was 90% to 100% effective in preventing precancerous cervical, vaginal, and vulvar lesions and genital warts caused by infection with the relevant HPV types (6, 11, 16, or 18) in women aged 15 to 26 years who were uninfected prior to vaccination.4,5 Additional immunogenicity and safety studies in 9- to 15-year-olds were performed for some AEFIs in prelicensure trials, those of unusual severity, or those that had received public attention. Statistical data mining, including proportional reporting ratios (PRRs) and empirical Bayesian geometric mean methods, were used to detect disproportionality in reporting.

See also pp 781 and 795.
olds demonstrated high seropositivity postvaccination; geometric mean antibody titers were as high as those of women aged 16 to 23 years in the efficacy trials and, by postvaccination month 7, were 1.7- to 2.7-fold higher.\textsuperscript{6}

In the clinical trials, the incidence of solicited systemic clinical adverse events following immunization (AEFIs) was similar in the vaccine group (59%) and the placebo group (60%). Headache was the most commonly reported systemic AEFI in both groups (qHPV, 28.2%; placebo, 28.4%). Proportions of fever (13.0\% vs 11.2\%) and nausea (6.7\% vs 6.5\%) were slightly higher in the vaccine recipients vs the placebo group. The rates of serious AEFIs were comparable between the 2 groups (<0.1\%). There was a slightly higher number of severe injection site reactions in the vaccine group (n = 10, 2.2\%) compared with the placebo group (n = 4, 0.9\%) in the 5 days after vaccination.\textsuperscript{1}

With more than 23 million qHPV doses distributed in the United States as of December 31, 2008 (number provided by manufacturer, http://www.cdc.gov/vaccinesafety/vaers/gardasil.htm), postlicensure safety monitoring can detect AEFIs too rare to have been detected during prelicensure trials. This article summarizes data from the US Vaccine Adverse Event Reporting System (VAERS) for the 2.5 years following licensure.

**METHODS**

We analyzed qHPV reports received by VAERS from June 1, 2006, through December 31, 2008. This voluntary, national, passive surveillance system was established in 1990 and is operated jointly by the US Food and Drug Administration (FDA) and the Centers for Disease Control and Prevention (CDC). Manufacturers, health care workers, patients or their parents, and others submit reports to VAERS.\textsuperscript{7} Although manufacturer reporting to VAERS is required, most information comes from physicians, patients, or other primary reporters.\textsuperscript{8} This analysis included only US reports to VAERS, which usually have more complete information and more feasible follow-up review of medical records than foreign reports. In addition, we had only US dose distribution data for calculation of reporting rates (RRs).

To code reported symptoms, VAERS uses a clinically validated, internationally standardized terminology, the Medical Dictionary for Regulatory Activities (MedDRA).\textsuperscript{9} Each report may have several assigned MedDRA codes. We searched the VAERS database using MedDRA codes for specific AEFIs of interest and predefined groups of MedDRA codes for local reactions and hypersensitivity reactions.

We classified VAERS reports as serious according to the FDA regulatory definition (21 CFR §314.80) of a serious AEFI as one that is life threatening; results in death, permanent disability, congenital anomaly, hospitalization, or prolonged hospitalization; or necessitates medical or surgical intervention to preclude one of these outcomes.\textsuperscript{10} We reviewed serious reports to identify primary AEs that needed further study. Onset interval is the number of days from the time of vaccination to the onset of earliest reported symptoms. The number of doses distributed in the United States (23 051 336), obtained from the vaccine manufacturer (number provided by manufacturer, http://www.cdc.gov/vaccinesafety/vaers/gardasil.htm), provided the denominator to estimate RRs.

Based on prelicensure safety data and the severity of or public attention to reported AEFIs, we performed detailed case reviews and separate analyses for syncope, dizziness, nausea, headache, local injection site reactions, hypersensitivity reactions including anaphylaxis, Guillain-Barré syndrome (GBS), transverse myelitis, pancreatitis, venous thromboembolic events (VTEs), deaths, and pregnancy outcomes.

Disproportionality screening with the empirical Bayesian geometric mean (EBGM) method, using Empirica WebVME software (Phase Forward, Waltham, Massachusetts), identified AEFIs reported during the first year of licensure that were more frequent than expected.\textsuperscript{11,12} We used the lower 5\% bound of the 90\% confidence interval for the EBGM (EB05) of 2 or higher, following criteria outlined by Szarfe-
Because VAERS is a legally mandated, government-sponsored surveillance system, institutional review board approval and informed consent were not required.

RESULTS

From June 1, 2006, through December 31, 2008, VAERS received 12,424 reports of AEFIs following receipt of qHPV (Table 1), an overall reporting rate of 53.9 reports per 100,000 vaccine doses distributed. The majority of reports (8471/12,424, or 68%) were submitted by the manufacturer, compared with an overall rate of 40% for VAERS reports on other vaccines. During the same time period, manufacturer reports accounted for 14.5% of the meningococcal conjugate vaccine reports and 7.5% of the reports for tetanus toxoid, reduced diphtheria toxoid, and acellular pertussis vaccine submitted to VAERS. Of the 8471 manufacturer reports for qHPV AEFIs, 7561 (89%) had insufficient identifying information to permit clinical follow-up or review. Additional sources of reporting included providers (17%), patients or parents (4%), state health clinics (1%), and “others” (11%).

In 9910 of 12,424 reports (80%), qHPV was the only vaccine identified. Patients received qHPV and quadrivalent meningococcal conjugate vaccine simultaneously in 775 of the AEFI reports (6%); the remaining 14% of reports described a variety of other vaccine combinations. Of the 8247 reports that included onset interval, 4393 (40%) occurred on the day of vaccination. Females accounted for 97% (12,039/12,424) of the patients for whom an AEFI was reported; the remaining 3% included males and reports with unspecified gender. Of 47 reports of qHPV administered to males, 25 (53%) were unintentional (medical errors with wrong vaccine administered), 17 (36%) were identified as off-label use, and 5 were from male HPV study participants. Among 9396 reports (77%) with dose information, 5772 (61%) followed the first dose, 2380 (25%) followed the second dose, and 1183 (13%) followed the third dose of qHPV. In addition, 61 (1%) inadvertently received 4 or more doses.

The most frequently reported AEFIs included syncope (n=1847, 15%), dizziness (n=1763, 14%), nausea (n=1170, 9%), headache (n=957, 8%), and injection site reactions (n=926, 7.5%). These overall aggregate numbers must be interpreted with caution since each VAERS report usually includes multiple codes; thus, there were 46,932 total codes for 12,424 reports, for an average of 3.7 codes per report (range, 2-10). Also, review of individual reports revealed coding errors and occasional duplicate coding.

### Serious Reports

Among the 12,424 AEFI reports, 772 (6.2%) were serious, including 32 reports of death, 20 of which had medical records, autopsy, or death certificates available for evaluation. Sources of serious VAERS reports included manufacturer (66%), patient/parent (11%), clinician (10%), state health clinic (1%), and “other” (12%). The most frequent serious symptoms included 159 reports of headache (21%), 119 nausea (16%), 113 dizziness (15%), 102 vomiting (13%), 102 pyrexia (13%), 102 fatigue (13%), and 98 syncope (13%). Medically important serious events included 8 reports of anaphylactic reaction (1%), 9 deep vein thrombosis (1.2%), 31 GBS (4%), 25 hypersensitivity (2.5%), 10 transverse myelitis (1.3%), 6 pancreatitis (0.8%), 14 pulmonary embolism (1.8%), 23 death (3%), 68 convulsion (8.8%), 30 urticaria (3.9%), and 9 autoimmune disorder (1.2%).

### Local Injection Site Reactions

There were 1741 reports with at least 1 of the MedDRA coding terms for local reactions (Table 2); 684 (39%) occurred on the day of vaccination. The median onset interval was 0 days after vaccination (same day as vaccination) with a range of 0 to 408 days; 1338 reports (77%) identified qHPV alone. The most common local reaction reports included injection site pain (n=926, 53%), injection site erythema (n=490, 28%), and injection site swelling (n=385, 22%). Forty-one reports (2%) involving local reactions were classified as serious. Review of these cases showed that 20 reports did not meet the FDA definition of serious; all of these were reported by the manufacturer. There were 4 cases reported as cellulitis and 1 case reported as an intra-articular injection. In the other 15 reports, local reactions were incidental and not the primary AEFIs contributing to severity.

### Syncope, Dizziness, and Nausea

There were 1896 reports with the coding term syncope or syncope vasovagal, 1572 with dizziness, and 1164 with nausea (Table 2). Only 62 reports de-

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**Table 1. Severity of qHPV Adverse Events Following Immunization in the United States by Age, Reported to VAERS June 1, 2006, Through December 31, 2008**

<table>
<thead>
<tr>
<th>Age Group, y</th>
<th>Death</th>
<th>Nonfatality</th>
<th>Serious</th>
<th>Nonserious</th>
<th>Total, No.</th>
<th>Reporting Ratea</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;9</td>
<td>0</td>
<td>0</td>
<td>41</td>
<td>41</td>
<td>82</td>
<td>0.2</td>
</tr>
<tr>
<td>9-10</td>
<td>0</td>
<td>11</td>
<td>160</td>
<td>171</td>
<td>192</td>
<td>0.7</td>
</tr>
<tr>
<td>11-12</td>
<td>2</td>
<td>60</td>
<td>950</td>
<td>1012</td>
<td>1184</td>
<td>4.4</td>
</tr>
<tr>
<td>13-17</td>
<td>9</td>
<td>332</td>
<td>4009</td>
<td>4350</td>
<td>5172</td>
<td>18.9</td>
</tr>
<tr>
<td>18-26</td>
<td>9</td>
<td>262</td>
<td>3687</td>
<td>3958</td>
<td>7644</td>
<td>17.2</td>
</tr>
<tr>
<td>&gt;26</td>
<td>0</td>
<td>16</td>
<td>258</td>
<td>274</td>
<td>432</td>
<td>9.9</td>
</tr>
<tr>
<td>Unknown</td>
<td>12</td>
<td>59</td>
<td>2547</td>
<td>2618</td>
<td>2884</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>32</td>
<td>740</td>
<td>11,652</td>
<td>12,424</td>
<td>37,108</td>
<td>53.9</td>
</tr>
</tbody>
</table>

Abbreviations: AEFI, adverse event following immunization; qHPV, quadrivalent human papillomavirus recombinant vaccine; VAERS, Vaccine Adverse Event Reporting System. a Reports per 100,000 doses distributed.
scribed all 3 events in the same individual. The qHPV was the only vaccine given in 74% of the syncope/vasovagal syncope reports, 73% of the dizziness reports, and 78% of the nausea reports. Of the reports describing syncope/vasovagal syncope, dizziness, or nausea, 94%, 90%, and 95%, respectively, were classified as nonserious. Among reports with known onset intervals, the event occurred on the same day as vaccination for 90% (1107/1228) of syncope reports, 75% (930/1233) of dizziness reports, and 63% (610/970) of nausea reports. Of the events that occurred on the day of vaccination and where a more specific time frame was given, more than half immediately (≤15 minutes) followed vaccination. Among the 1896 syncope reports, 293 (15%) resulted in a fall and 200 falls (68%) resulted in a head injury. Head injuries included 9 fractures (6 nose, 2 skull, and 1 maxillary), 18 dental injuries, 9 concussions, 17 contusions, 5 intracranial hemorrhages (1 subdural hematoma, 1 subarachnoid hemorrhage, 3 not otherwise specified), and 45 lacerations (38 of which required sutures). In addition, there were 7 reports of contusions on elbows or knees. The EB05 (2.28) for syncope was the only positive signal identified with EBGM methods.

**Headaches**

There were 937 reports of headaches after qHPV vaccination (Table 2). These accounted for 7.7% of the total AEFls reported. One hundred fifty of these reports (16%) were coded as serious. The most common reason for being classified as a “serious” report was hospitalization for neurologic evaluation after a syncope-related fall.

**Hypersensitivity Reactions**

There were 725 reports with a coding term indicative of hypersensitivity (Table 2). Review of the reports showed that 31 reports were coded incorrectly. In addition, there was 1 hearsay case that could not be evaluated, leaving 693 total hypersensitivity cases. Of the 693 hypersensitivity reports, 416 (60%) were from the manufacturer, 178 (26%) were from the health care professional, 24 (3%) were from a parent or patient, and 75 (11%) were from an “other” source.

Hypersensitivity reports included 600 of urticaria (87%); 95 rash (14%); 95 pruritus (14%); 42 arthralgia (6%); 28 anaphylactoid reaction (4%); 23 generalized rash (3%); 22 pruritic rash (3%); and rare reports (<1%) of angioedema, dermatographism, serum sickness, bronchospasm, and eye swelling. Five hundred fifty-six reports (80%) were attributed to qHPV alone.

The time interval between vaccination and onset of symptoms could not be calculated for 150 reports. For the reports where time interval was available, more than half of the cases were reported on the same day as (n=246, 35%) or the next day after (n=126, 18%) vaccination. The median onset interval was 1 day with a range of 0 to 271 days. No dose information was provided in 106 reports; 82 of these (77%) were manufacturer reports. Most hypersensitivity reports (n=393, 78%) occurred after dose 1, 160 (23%) occurred after dose 2, and 53 (8%) occurred after dose 3. The overall RR was 3.1 of 100 000 doses distributed.

There were 600 reports of urticaria to VAERS, including 178 reports (30%) of generalized urticaria, 33 reports (5.5%) associated with the injection site or arm, 114 (19%) on localized sites (including 42 on the upper body, 3 on the lower body, 18 on the torso, 11 on the arms and legs, 8 on the legs bilaterally, 10 on the arms bilaterally, and 22 on the face/head), and 8 reports (1%) of fewer than 10 hives scattered over the body. There were 267 reports (44.5%) that did not specify the location of the urticaria. Most reports of urticaria (n=329, 55%) occurred after dose 1, 135 (22%) occurred after dose 2, and 46 (8%) occurred after dose 3. No dose information was provided in 90 reports; 69 of these (77%) were manufacturer reports. The

### Table 2. Most Common and Other Selected qHPV Adverse Events Following Immunization in the United States, Reported to VAERS June 1, 2006, Through December 31, 2008

<table>
<thead>
<tr>
<th>AEFla</th>
<th>Serious Adverse Events</th>
<th>Nonserious Events</th>
<th>qHPV Aloneb</th>
<th>Total, No.</th>
<th>Reporting Ratec</th>
</tr>
</thead>
<tbody>
<tr>
<td>Syncope, syncope vasovagal</td>
<td>93 (5)</td>
<td>1803 (95)</td>
<td>1396 (74)</td>
<td>1896</td>
<td>8.2</td>
</tr>
<tr>
<td>Local reactiond</td>
<td>41 (2)</td>
<td>1700 (98)</td>
<td>1338 (77)</td>
<td>1741</td>
<td>7.5</td>
</tr>
<tr>
<td>Dizziness</td>
<td>96 (6)</td>
<td>1476 (94)</td>
<td>1147 (73)</td>
<td>1572</td>
<td>6.8</td>
</tr>
<tr>
<td>Nausea</td>
<td>119 (10)</td>
<td>1045 (90)</td>
<td>908 (78)</td>
<td>1164</td>
<td>5.0</td>
</tr>
<tr>
<td>Headache</td>
<td>150 (16)</td>
<td>787 (84)</td>
<td>688 (73)</td>
<td>937</td>
<td>4.1</td>
</tr>
<tr>
<td>Hypersensitivity reactione</td>
<td>47 (6)</td>
<td>678 (94)</td>
<td>582 (80)</td>
<td>725</td>
<td>3.1</td>
</tr>
<tr>
<td>Urticaria</td>
<td>22 (4)</td>
<td>590 (96)</td>
<td>501 (82)</td>
<td>612</td>
<td>2.6</td>
</tr>
<tr>
<td>Venous thromboembolic event</td>
<td>39 (69)</td>
<td>17 (31)</td>
<td>55 (98)</td>
<td>56</td>
<td>0.2</td>
</tr>
<tr>
<td>Autoimmune disorder</td>
<td>19 (37)</td>
<td>32 (63)</td>
<td>45 (88)</td>
<td>51</td>
<td>0.2</td>
</tr>
<tr>
<td>Guillain-Barré syndrome</td>
<td>31 (74)</td>
<td>11 (26)</td>
<td>25 (60)</td>
<td>42</td>
<td>0.2</td>
</tr>
<tr>
<td>Anaphylaxis</td>
<td>8 (29)</td>
<td>20 (71)</td>
<td>18 (64)</td>
<td>28</td>
<td>0.1</td>
</tr>
<tr>
<td>Death</td>
<td>32 (100)</td>
<td>0</td>
<td>23 (72)</td>
<td>32</td>
<td>0.1</td>
</tr>
<tr>
<td>Transverse myelitis</td>
<td>10 (100)</td>
<td>0</td>
<td>10 (100)</td>
<td>10</td>
<td>0.04</td>
</tr>
<tr>
<td>Pancreatitis</td>
<td>9 (100)</td>
<td>0</td>
<td>9 (100)</td>
<td>9</td>
<td>0.04</td>
</tr>
<tr>
<td>Motor neuron disease</td>
<td>2 (100)</td>
<td>0</td>
<td>2 (100)</td>
<td>2</td>
<td>0.009</td>
</tr>
</tbody>
</table>

Abbreviations: AEFl, adverse event following immunization; qHPV, quadrivalent human papillomavirus recombinant vaccine; VAERS, Vaccine Adverse Event Reporting System.

a Using MedDRA terms. More than 1 code may be assigned to a single report.

b No other vaccine was coadministered.

cReports per 100,000 doses distributed.

dLocal injection site reaction MedDRA codes include injection site abscess, injection site abscess sterile, injection site atrophy, injection site cyst, injection site desquamation, injection site hemorrhage, injection site hypersensitivity, injection site inflammation, injection site mass, injection site necrosis, injection site nodule, injection site edema, and injection site pain.

eHypersensitivity reaction MedDRA codes include anaphylactic reaction, anaphylactic shock, anaphylactoid reaction, cross-sensitivity reaction, dermatographism, hypersensitivity, urticaria, urticaria thermal, and urticaria vesicular.

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median time interval from immunization to onset of symptoms was 17 days, with a range of 8 to 49 days. The overall RR was 2.6 cases per 100,000 doses distributed.

There were 28 reports coded as anaphylaxis after qHPV (Table 2). Two cases were hearsay reports without any medical information, leaving 26 cases for review. Seventeen of these cases (65%) occurred after dose 1, 4 (15%) occurred after dose 2, 1 case (4%) occurred after dose 3, and the dose number was unknown for 4 cases (15%). Review using the Brighton classification criteria found that 7 (27%) did not meet the criteria for anaphylaxis, 9 (35%) had insufficient information, and 10 (38%) met the Brighton anaphylaxis definition. Only 4 cases were of sufficient concern to be referred to an allergist.

Transverse Myelitis
There were 10 cases of transverse myelitis reported to VAERS (Table 2). Two cases had insufficient information for adequate clinical review and 1 case was diagnosed as multiple sclerosis. All 7 confirmed transverse myelitis cases were found after qHPV vaccine alone. The age distribution of cases was 13 to 26 years. One case occurred after dose 1, and 6 cases occurred after dose 2. Only 1 case occurred within the theoretical 4- to 42-day window of biological plausibility.18

Motor Neuron Disease
There were 3 reports to VAERS of young females who presented with a rapidly progressing neurologic disorder occurring some months after receipt of the qHPV vaccine. One of these reports was a hearsay report (a fifth-hand report) that could not be identified and might represent 1 of the other 2 cases. Autopsy confirmed a diagnosis of amyotrophic lateral sclerosis (anterior motor neuron disease) in 1 case. The other young female died in 2009. The autopsy findings on this case are still pending.

Venous Thromboembolic Events
Based on MedDRA search terms of venous thrombosis, thrombosis, embolism, pulmonary embolism, deep vein thrombosis, pulmonary thrombosis, and embolic stroke, there were 56 reports of VTEs after qHPV, for an RR of 0.2 case per 100,000 doses. Ten cases were hearsay reports that could not be confirmed or clinically evaluated, 9 reports were related to “clots with menses” and were not VTEs, 5 were manufacturer reports with no identifying information for follow-up, 1 report had insufficient information available for adequate evaluation, and 31 reports had sufficient information for clinical review. There were 5 reports of deep vein thrombosis alone, 7 reports of deep vein thrombosis with pulmonary embolism, 12 reports of pulmonary embolism without deep vein thrombosis, 4 reports of cerebrovascular accidents, 1 report of superior mesenteric vein thrombosis, and 2 reports of superior sagittal venous thrombosis. There were 4 deaths reported among the 19 pulmonary embolism cases (21%).

Thirty of 31 reports (97%) were associated with qHPV immunization alone. The mean age of individuals reported to have VTEs after qHPV immunization was 21 years (median, 20 years; range, 15-39 years). The number of doses preceding the diagnosis of a VTE included 9 cases after dose 1, 11 cases after dose 2, and 10 cases after dose 3; dose number was unknown for 1 case. The mean time between qHPV immunization and diagnosis was 41.5 days (median, 23 days; range, 0-306 days).

Risk factors included estrogen-containing birth control (n=20), family history (n=10), history of smoking (n=2), immobility (n=7), overweight (n=6), increased triglycerides (n=1), history of surgery (n=1), pregnancy (n=2), trauma from surfing (n=1), and hyperviscosity from diabetic ketoacidosis (n=1). Twenty-eight of 31 cases (90%) had a known risk factor for VTEs. Twenty-two of 31 cases (71%) were tested for hypercoagulability; 10 were positive, including 2 cases with factor V Leiden deficiency, 2 cases...
with methylenetetrahydrofolate reductase deficiency, 1 case with methylene-
tetrahydrofolate reductase deficiency with increased homocysteine levels, 1
case with the prothrombin gene mutation with methylenetetrahydrofolate re-
ductase deficiency, 1 case with a pro-
thrombin mutation and increased homocysteine levels, and 2 cases of an-
tiphospholipid syndrome. All 10 cases with hypercoagulability had a known
risk factor for VTEs, including 7 with a history of taking estrogen-containing
birth control medications.

The PRR for 6- to 17-year-olds was 4.8
($\chi^2 = 4.16, P = .04$). The PRR for 18- to 29-
year-olds was 6.7 ($\chi^2 = 7.48, P = .006$).
Both of these age groups met the screening
criteria for signal detection.

Pancreatitis
There were 10 reports coded as pancre-
atitis in VAERS. One case was ultima-
tely diagnosed with multiple ovarian
cysts as the cause of the patient’s right lower quadrant pain, leaving 9 reports of pancreatitis. All of the cases had risk factors for pancreatitis, including gall-
stones (n=2), alcohol use (n=1), in-
creased triglycerides (n=1), viral infec-
tion (Coxsackie) (n=1), estrogen use
(n=2), and mild obesity (n=2). All cases
were hospitalized, meeting the FDA de-
nition of a serious AEFI. Three cases pre-
SENTED after dose 1, 3 after dose 2, and 3
after dose 3. Two of the individuals who
presented after dose 1 had resolution of
symptoms but experienced subsequent exacerbations after doses 2 and 3. It was not possible to do any statistical com-
parisons because of low numbers.

Autoimmune Disorders
There were 51 reports of autoimmune disorders to the VAERS system, includ-
ing 26 reports of autoimmune disor-
der (not otherwise specified), 1 report of scleroderma, 1 report of dermat-
omyositis, 18 reports of systemic lupus erythema-
tosus, 13 reports of rheuma-
toid arthritis, 1 report of Sjogren syn-
drome, and 4 reports of mixed connec-
tive tissue disease. Fifty-one of these
reports (88%) were associated with
qHPV vaccine alone.

Pregnancy
There were 236 VAERS reports of qHPV
given shortly before or during preg-
nancy. Twelve of the AEFI reports were
coded as serious; 10 required hospital-
dization due to miscarriage and 2 cases
included a life-threatening illness (1
deep vein thrombosis and 1 severe vagi-
nal hemorrhage after emergency dil-
ation and curettage). Two hundred
twenty-eight reports (97%) were re-
ceived from the manufacturer through the
Merck Pregnancy Registry.

One hundred forty-three of the re-
ports were coded as miscarriage (spon-
taneous abortion), including 1 molar
pregnancy. There were 75 reports of
elective termination of pregnancy fol-
lowing administration of qHPV. None
of the reports described receipt of qHPV
having influenced the decision to ter-
minate the pregnancy. There were 13
deliveries of normal, healthy infants; 3
ectopic pregnancies; and 2 unknown
pregnancy outcomes.

Deaths
There were 32 VAERS reports of death
following qHPV vaccination (Table 2).
Eight of the reports were second-hand
reports that could not be verified. Four
were manufacturer reports with no iden-
tifying information for confirmation
or medical review. Twenty of the
reports (62.5%) could be verified through
clinical review of medical records
and autopsy reports. Of these
cases, 14 (70%) were after qHPV alone.
The other 6 cases reported qHPV as well
as a variety of other vaccines. Nine cases
occurred after dose 1, 5 after dose 2, and
6 after dose 3.

Mean age was 18 years (median, 17
years; range, 12-26 years). There was
no clustering by age. The mean time
from last qHPV immunization to AEFI
onset was 39 days (median, 14.5 days;
range, 2-288 days). The mean time from
last qHPV immunization to death was
47 days (median, 14.5 days; range, 2 to
405 days).

Causes of death included 4 unex-
plained deaths, 2 cases of diabetic ke-
toacidosis (1 complicated by pulmo-
nary embolism), 1 case related to
prescription drug abuse, 1 case of ju-
venile amyotrophic lateral sclerosis, 1
case of meningocencephalitis (Neissec-
teria meningitidis serogroup B), 1 case of
influenza B viral sepsis, 3 cases of pul-
mmonary embolism (1 associated with
hyperviscosity due to diabetic ketoacido-
dosis), 6 cardiac-related deaths (4 ar-
rhythmias and 2 cases of myocarditi-
s), and 2 cases due to idiopathic seizure
disorder.

The PRR for deaths in 6- to 17-year-
olds was 1.4 ($\chi^2=0.42, P=.52$). The PRR
for deaths in 8- to 29-year-olds was 1.2 ($\chi^2=0.01, P=.92$). Neither of these met
the screening criteria for signal detect-
ion.

COMMENT
Our review of 12,424 reports of AEFIs
following receipt of qHPV after licens-
sure found that most did not meet the
FDA definition of serious. The safety pro-
file described by these data for fre-
quent AEs is consistent with prelicen-
sure data, with the exception of syn-
cope and VTEs. This review summarizes
passive surveillance data from more
than 23 million doses distributed in the
United States. Such postlicensure moni-
toring allows for the potential detec-
tion of rare AEFIs as more people are
vaccinated. As expected with increased
numbers of immunizations in the postlicensure setting, rare AEFIs
were observed more often than in the
prelicensure review.

Ongoing monitoring will help as-
sess whether the serious reports to
VAERS, as well as the few serious AEs
identified during prelicensure trials, re-
quire further evaluation.22 The Vac-
cine Safety Datalink is providing addi-
tional surveillance through the use of
rapid cycle analyses to monitor for sei-
zures, syncope, anaphylaxis, appendi-
citis, GBS, and VTEs.23 Important iden-
tified concerns from either VAERS or
the Vaccine Safety Datalink can be in-
vestigated using well-designed, system-
atic, hypothesis-driven studies.

Reported deaths with available rec-
ords, autopsy reports, or death certifi-
cates describe causes other than re-
cent vaccination. Two of 3 VTE death
PORTS TO VAERS INCREASED, PRIMARY

The population of young women who frequently use hormonal contraceptives overlaps with those receiving the qHPV vaccine, coincidental occurrences of VTE among qHPV recipients may be anticipated. Nonetheless, close monitoring continues for VTE reports to VAERS following qHPV and other vaccines.

Vasovagal syncope is among the most frequently reported AEFIs following qHPV. When it results in falls, significant traumatic injuries can occur.25,26 The ACIP and Red Book have published guidelines to prevent vasovagal syncope and related injury following vaccination.27,28 After several newly licensed adolescent vaccines (qHPV; quadrivalent meningococcal conjugate vaccine; and tetanus toxoid, reduced diphtheria toxoid, and acellular pertussis vaccine) were added to the routine immunization schedule, the number of postvaccination syncope reports to VAERS increased, primarily among females aged 11 to 18 years.29 This age group also has a higher background rate of syncope than other age groups. The predominance of females could be related to an actual difference between the sexes or could represent reporting bias since the qHPV vaccine is currently licensed for females only. With the increased use of adolescent vaccines, we strongly urge vaccine providers to diligently implement the ACIP recommendations for a routine 15-minute waiting period following vaccination. There have been reports in the literature documenting seizure-like activity during syncope in children.30,31 Some reports to VAERS of seizures may be anoxic seizures resulting from syncopal episodes.

Reports of VTEs after qHPV immunization should be interpreted with caution due to the multiple limitations of a passive reporting system and the potential effect of widespread media coverage stimulating reporting. These cases occurred over a wide time interval after immunization, and 90% reported a known risk factor for VTEs. It is difficult to establish a potential window of biological plausibility since the time frame between risk factor exposure and clot formation is unknown. We did not detect any signal for VTEs through data mining or in the Vaccine Safety Datalink. Continued monitoring will be done for cases in VAERS, the Vaccine Safety Datalink, and potential future studies.

Our review of definite and possible GBS reports revealed a lower RR (0.3/100,000 estimated person-years based on dose distribution) than the background incidence rate of GBS in 9- to 26-year-old females (1.57/100,000 person-years). We did not detect any signal for GBS through data mining or in the Vaccine Safety Datalink, although the extent of underreporting to VAERS is not known.30

Because there are no adequate and well-controlled studies in pregnant women, and animal reproduction studies are not always predictive of human response, qHPV is not recommended for use in pregnant women.3 Exposure to qHPV during pregnancy have been identified in VAERS. As agreed with the FDA at the time of licensure, the vaccine manufacturer established a voluntary pregnancy registry to monitor outcomes among women vaccinated with qHPV during the month prior to conception or during pregnancy.3 This pregnancy registry is more complete than VAERS reporting and includes continued follow-up of cases. Although VAERS shares inherent limitations of all passive surveillance systems, it is national in scope and can provide important signals that may require further attention.3 However, VAERS data need to be interpreted with caution, because not all reported events are systematically validated, and many may have only coincidentally followed vaccination. In addition, data limitations include underreporting, inconsistency in the quality and completeness of reported data, stimulated reporting due to extensive news coverage, and reporting biases.7 The VAERS reporting rate for qHPV is triple the rate for all other vaccines combined, perhaps reflecting greater public attention to HPV than the usual increased reporting following licensure of a new product (“Weber effect”).32,33 AEFI reporting rates also need cautious interpretation, because vaccine distribution data do not allow calculation of age-specific reporting rates and do not provide the numbers of doses actually administered.

A further limitation of VAERS reports after qHPV is that a large proportion (68%) come from the manufacturer and most of these reports (89%) do not include sufficient identifying information to allow medical review of the individual cases. For example, when additional clinical information was available for review, approximately one-half of the cases of GBS and transverse myelitis were not confirmed.

Postlicensure safety surveillance of qHPV supplements data from the prelicensure randomized clinical trials. Ongoing VAERS monitoring also complements 2 large ongoing postlicensure observational safety studies: the CDC-sponsored Vaccine Safety Datalink “rapid cycle analysis” and a phase IV study agreed on by the manufacturer and the FDA at the time of vaccine licensure.1,34 The latter study will provide data on the safety of simultaneous use of qHPV with other recommended vaccines, as well as autoimmune and serious AEFIs reported after qHPV vaccination. The pregnancy registry will continue for at least 5 years.

CONCLUSION

Vaccination with qHPV has the potential to decrease the global morbidity and mortality of HPV-associated diseases, including cervical cancer. After hepatitis B vaccine, which can prevent liver cancer, qHPV is only the second vaccine licensed with an indication to prevent cancer. The postlicensure safety profile presented here is broadly consistent with safety data from prelicensure trials. Because VAERS data must be interpreted cautiously and cannot generally be used to infer causal asso-

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citations between vaccines and AEFIIs, postlicensure monitoring will con-
tinue, and identified signals may be evaluated using epidemiologic observ-
rational studies.

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