
Col Les R. Folio, DO, MPH, USAF, MC
Lt Col Eveline F. Yao, MD, USAF, MC

Context: President George W. Bush announced a national smallpox vaccination program (SVP) on December 13, 2002, for military personnel, civilian healthcare workers, and “first responders.” The program was intended to protect these individuals against exposure to weaponized smallpox. The US Air Force (USAF) began implementation of the SVP on January 7, 2003.

Objectives: To determine if the SVP affected USAF personnel readiness, and, based on these results, to determine the overall safety of a large-scale SVP.

Methods: A retrospective cohort study of duty-restriction (DNIF) rates measured by duties not to include flying (DNIFs) of 17 aircrews in the USAF Air Mobility Command (AMC). Data from January 2002 to May 2002 (prevaccination) and January 2003 to May 2003 (vaccination) were compiled by month from three of the 11 AMC bases. Total DNIFs associated with or attributed to the smallpox vaccine were recorded. In addition, total 2003 DNIFs in 1662 study subjects (678 [40.8%] of whom received smallpox vaccination) were recorded and compared with total 2002 DNIFs in 1602 control subjects before SVP implementation. Differences in monthly DNIF rates were calculated using the one-tailed paired t test.

Results: In the 678 subjects who received smallpox vaccination, 13 vaccine-related DNIFs (1.9%) occurred. Differences in DNIF rates were statistically significant (P<.05) during 2 months at one AMC base. However, the SVP did not increase overall DNIF rates in the SVP study period.

Conclusions: With DNIF status as a health marker, the SVP did not impose operational constraints or adversely affect aircrew preparedness in the USAF AMC. The authors suggest that a similar SVP with comparable screening measures would indicate the overall safety of the vaccine.

J Am Osteopath Assoc. 2007;107:547-553

The eradication of smallpox is arguably one of the greatest triumphs in public health history. The scourge of this disease dates back to the Egyptian-Hittite War in 1350 BC. Smallpox spread from Egyptian prisoners to the Hittite population, launching the first recorded epidemic in human history.1 The Spanish settling of Mexico and the selling of slaves from Africa, where smallpox was prevalent, to the Americas further expanded smallpox’s reach and devastation. In the late 18th century, smallpox was reported responsible for 400,000 deaths per year in Europe.2 Overall, an estimated 30% of all smallpox cases caused by variola major were fatal, and survivors were left disfigured and often blind as a result of secondary corneal infections.3

In warfare, Hannibal used biologic agents against the Romans in 190 BC, and the plague was used in the siege of Kaffa in 1346.4 Smallpox was an agent of biologic warfare during the French and Indian Wars (1754-1767) by the British against Native Americans. British forces distributed blankets as fomites with smallpox pustule scabs to Native Americans; infected tribes had a 50% attrition rate.1,4

In 1796, Dr Edward Jenner discovered that protection and immunity from variola virus could be conferred with inoculation of a related genus orthopoxvirus: cowpox.1 This discovery—and the subsequent use of cowpox as an inoculation against smallpox—saved countless lives. The vaccine, which today is derived from attenuated live vaccinia virus, eventually led to smallpox’s downfall. The last case of naturally acquired smallpox was recorded on October 26, 1977, in Africa.5,6 The World Health Organization (WHO) declared the virus eliminated on October 26, 1979, relegating the disease to history:

The day was designated Smallpox Zero day, and it occurred 12 years, 9 months, and 26 days after [the] WHO embarked on its global eradication program, and 178 years after [Edward] Jenner foresaw the possibility of smallpox eradication through vaccination.2

By 1983, only the Soviet Union and the US Centers for Disease Control and Prevention (CDC) in Atlanta, Ga, had stocks of variola virus.7

However, today, despite—or because of—the WHO’s eradication program, smallpox has reemerged as a potential biologic weapon.8 By modern standards, a bioterrorist act
such as the deliberate release of variola would be “an international crime of unprecedented proportions.” The containment of unleashed smallpox virus in an age of globalization would be a titanic public health undertaking. In the event that smallpox is used in biologic warfare, the CDC would initiate its proposed ring vaccination scheme as performed during the smallpox eradication effort. However, these actions, such as the possibility of a mandated quarantine, could cause public protests.

As a precautionary measure, the US Department of Defense (DoD) called for the vaccination of 500,000 military personnel shortly after President George W. Bush announced a national smallpox vaccination program (SVP) in 2002. In accordance with the DoD policy, the US Air Force (USAF) introduced the Smallpox Vaccination Implementation Plan on January 7, 2003. Unless medically exempt, USAF service members were grouped by priority and then designated for mandatory vaccination under a phased approach. However, because documented risks of the vaccine existed and the risk of the threat of enemy action was unquantified, this program was controversial.

In the 1960s, epidemiologic studies identified life-threatening reactions after smallpox vaccination: postvaccinal encephalitis and progressive vaccinia. Myopericarditis, a third reaction identified in studies from 2003, is also potentially life-threatening. A summary of these studies’ findings follow:

- In 1968, the first study on the frequency of adverse effects (based on national surveillance data using the New York City Board of Health Strain of Vaccinia) was conducted. For people aged 20 years and older, the study found an overall mortality rate of 1 per 1 million primary vaccinations and 1 per 4 million revaccinations. The study, in providing the highest quality epidemiologic evidence, became the principal reference for smallpox experts and national public health professionals. It concluded with a reaffirmation that “the morbidity and mortality associated with smallpox vaccination in the United States are considerable” compared with the lack of smallpox cases in the United States at the time.

- In August 2003, Aragon and colleagues published a systematic review of the United States’ experience with smallpox vaccination from 1963 to 1968, comprising data on more than 13 million primary vaccinations and 18 million revaccinations. The study reported a postvaccinal encephalitis mortality rate of 3 per 1 million vaccine recipients and a progressive vaccinia mortality rate of 1 per 1 million vaccine recipients.

- In 1971, Kemper and colleagues developed a model to predict expected adverse effects in a mass smallpox vaccination program, assuming approximately 25% exemptions following prevaccination screening and rigid adherence to guidelines. The model predicted fever in 1 case per 5 vaccine recipients and rash in 1 case per 100 vaccine recipients. It also predicted 2 deaths per 1 million vaccine recipients.

Grabenstein and Winkenwerder published surveillance data on the US Military SVP experience, describing the first 450,293 vaccinations from December 13, 2002, through May 28, 2003. The study reported that 0.5% of hospital vaccine recipients and 3.0% of deployed recipients of the vaccine required short-term sick leave. One case of encephalitis and 37 incidences of acute myopericarditis were reported; all patients recovered. Expected temporary symptoms occurring after vaccination included pruritis (60%), malaise (21%), malaise (20%), headache (18%), lymphadenopathy (14%), irritation from bandage sites (7.4%), subjective reported fever (5.3%), and site rash (5.3%). Approximately 1% of primary vaccine recipients experienced skin eruptions beyond the inoculation site. The study’s analysis indicated additional adverse effects following smallpox vaccination.

Although no deaths were attributed to smallpox vaccination in the Grabenstein and Winkenwerder study, concerns about the safety of the vaccine remained.

Because of these concerns, the SVP was modeled after lessons learned from the Anthrax Vaccine Immunization Program, which has been fraught with—scientifically unsupported—controversy. Folio and colleagues, however, demonstrated overall safety through short-term follow-up of the anthrax vaccine administered in a deployed military population of more than 5000 people.

Given the well-documented adverse effects of the smallpox vaccine, we sought to describe the possible occupational and operational hazard of the SVP using duty-restriction rates in the USAF Air Mobility Command (AMC). These rates acted as a proxy measure to aid military understanding of the impact of the SVP on mission performance during the initial phase of program implementation. Because smallpox vaccination is associated with untoward—but temporary—symptoms, the SVP was implemented with caution. Abnormally high duty-restriction rates, which were measured by duties not to include flying (DNIFs), could negatively impact the USAF’s air mobility mission capability, wartime readiness, and the timing of smallpox vaccination. The current study examines the operational impact of the DoD’s SVP on 3 of 11 AMC bases and whether or not the vaccine had a significant adverse effect on personnel readiness.

Methods

This retrospective cohort study investigates the impact of smallpox vaccination on active-duty C-17 AMC aircrews, assessing and documenting the possible adverse effect on operational preparedness. A comparison is made between total DNIF rates during initial implementation of the SVP (study period) with total DNIFs during an equivalent period.
before the SVP was employed (control period). Because DNIFs are assigned only under specific conditions, such as when an illness or condition may affect aircrew safety (eg, alertness), they are considered highly sensitive health indicators.

The AMC at any given time is composed of anywhere from 9 to 11 bases with a total of approximately 51,500 active-duty personnel.²¹ Data were collected from three of these bases (base 1, base 2, and base 3) for the current study. Subjects included active-duty pilots, navigators, refueling boom operators, loadmasters, and flight surgeons in C-17 aircrews, all of whom receive integrated healthcare from their respective primary care USAF Flight Medicine Clinics. These clinics are staffed with flight surgeons of varying medical specialties, including family practice and internal medicine. Air Reserve Component personnel and other special operators, such as air traffic controllers, air weapons controllers, and combat controllers, were excluded from the study and control groups.

The study group was composed of approximately 1662 active-duty aircrew from bases 1, 2, and 3 during SVP implementation—the study period—from January 2003 through May 2003. Study subjects comprised both those who received the smallpox vaccine as well as those who did not receive the vaccine during the stated time period. The control group consisted of about 1602 active-duty aircrew from the same bases before SVP implementation—the control period—from January 2002 through May 2002. These aircrew numbers are approximate because total aircrew at any given base fluctuate month to month. Real aircrew numbers were totaled for each month of each year. Subject history and demographic data were not compiled for the study or control group. Stringent requirements of health as outlined in Air Force Instruction 48-123,²³ which encompasses an extensive list of disqualifying conditions, must be met in order to receive flying status. Therefore, in general, this population was healthy.

Data for DNIFs and SVP status were obtained at each of the three study sites in accordance with the 1996 Health Insurance Portability and Accountability Act (HIPAA) guidelines. No personal identifiers were retained in the final data tabulated in the current study, maintaining subject confidentiality in all cases. Other unique identifiers used for tracking and research purposes, however, were unrelated to personal data and were also in compliance with HIPAA guidelines. This activity was reviewed and approved as exempt from institutional review board oversight in compliance with the DoD’s policy for protection of human subjects (32 CFR 219) and Air Force Instruction 40-402.

The 5-month study period spanned the initial implementation period for the SVP. During this time frame, 678 vaccinia inoculations were administered among eligible screened aircrew individuals in the study population. Data from SVP records showed an exemption rate of approximately 11% among all screened individuals, which included aircrew personnel. Smallpox vaccination exemptions included both medical (eg, pregnancy) and administrative (eg, vaccination refusal) reasons.¹⁰

All USAF clinics maintain DNIF data on USAF Form 1041, which lists crew member name, identifier, specialty code, date DNIF status was assigned, date DNIF status was removed, duration of DNIF status, and diagnostic code indicating reason for DNIF. These logs were used to obtain the number of DNIF designations per month in the study period and the control period.

Each USAF base has its own unique characteristics, practices, policies, and operational pressures that may affect aircrew members receiving DNIF status. To adjust for as much unmeasured confounding as possible, the same bases were compared for 2002 and 2003. To isolate the effect of the vaccination, we assumed that the same pressures were present in the same quantities in 2002 and 2003 for each separate base. Although approximately two thirds of the population at USAF bases remains the same each year, we considered the study population independent of the control population. In other words, we assumed that DNIF status for each month in 2002 did not affect DNIF status in each month of 2003. In addition, subjects were considered independent for each month (ie, one aircrew member receiving DNIF status had no effect on any other individual receiving DNIF status).

To assess the occurrence of vaccine-related adverse events in subjects, the number of DNIFs attributed to and associated with the smallpox vaccine were totaled. Symptoms attributed to the smallpox vaccine were defined as symptoms examined by a flight surgeon, diagnosed as a result of the vaccine, and then annotated as such in the USAF log. Likewise, symptoms temporally associated with the vaccine were defined as occurring within 12 days of inoculation, with the peak adverse effect profile occurring 8 to 12 days postvaccination. In other words, among vaccine recipients, DNIF statuses that occurred within 12 days postvaccination were automatically considered vaccine-related.

To determine whether the SVP affected personnel readiness, total DNIFs in the study population—which comprised both vaccine recipients and nonrecipients—were compared with total DNIFs in the control population of the previous year (ie, prevaccination). Data for total aircrew and total DNIFs per base were compiled by month. Each DNIF status was classified according to each month. By this definition, a subject who had a status of DNIF several times during a month, 20 days during the month, or only 1 day were all treated as one DNIF event. An individual whose DNIF status continued into the next month was counted in both months.

Differences in DNIF rates between months were analyzed using a 1-tailed paired t test. The 1-tailed t test was chosen rather than the 2-tailed t test because the 1-tailed test does not require the response variables to follow a normal distribution. However, as a result of the magnitude of the cohort available for analysis, both tests would have nearly identical results.
Results

Between the months of January 2003 and May 2003, vaccines were administered to 678 (40.8%) of 1662 study subjects (Table 1). Vaccine-attributed DNIFs occurred in 4 (0.6%) of the vaccinated subjects, and vaccine-associated DNIFs occurred in 9 (1.3%) of the vaccinated subjects (Table 2). The specific adverse effects were not available.

Proportions of DNIFs in the study population were not significantly different when 2003 data were compared with data from the control population the previous year. No consistent difference occurred in DNIF rates from the study period vs the control period (Table 3).

For bases 1 and 2, no months had significantly higher DNIF rate in 2003 than in 2002. In fact, the rate was found to be substantially lower in May 2003 compared with May 2002 at base 1. For three of the months at base 2, the DNIF rate was much lower. Interestingly, the DNIF totals at base 2 in February 2003, the single month in which the most people where vaccinated at any of the bases, had an almost identical DNIF rate as in 2002.

The only evidence that the SVP might increase DNIF rates occurred at base 3. The higher DNIF rates were statistically significant when compared with the 2002 rates for base 3 in February and March ($P= .025$ and .005, respectively). In addition, the DNIF rates increased at base 3 in January and May, but they were not statistically significant. April had only a slight drop. The month-to-month comparison of each base (Table 3) yielded only these two instances of significantly higher DNIF rates in the study population compared with the control population.

A comparison of average DNIF rates for each base revealed similar results for the study and control populations. Average rates of DNIFs for base 1 and base 2 decreased when comparing the control population with the study population, from 19.7% to 19.1% at base 1 and 8.3% to 5.3% at base 2. However, the average DNIF rate increased from 12.5% to 15.0% at base 3. As noted previously, this base had significantly higher DNIF rates in the study population than the control population for 2 months ($P < .05$). The overall DNIF rates were 13.5% in 2002 and 13.1% in 2003, showing a slight decrease in DNIF rates in the total study population.

Discussion

Although overall DNIF rates were not higher than baseline in the period encompassing the SVP, which we believe indicates the overall safety of the SVP in the USAF, there are several limitations to the current study. For example, the study population is small, especially when compared with other smallpox vaccination studies. Also, as a result of the small number of vaccine-related events, any significant difference cannot be attributed to the SVP as the root cause leading to the statistically significant increases in DNIF rates at base 3. Because subject characteristics were not recorded, we are unable to determine if study and control population characteristics were a factor.

According to flight documents, operations level of task load were comparable in both periods at baseline (ie, aircrew tasks were equally numerous during the study and control periods). Using the same period for comparison minimized seasonal variation of disease (eg, both periods occurred during influenza and cold season). Ease of access to medical care might have been a mitigating factor. The flight surgeon staffing was essentially unchanged. Rates of other illnesses were similar in 2002 and 2003.

Because USAF 1041 forms are not always recorded immediately after an individual receives DNIF status, the number of vaccine-attributed events may be underestimated. For example, the lack of documentation of diagnostic codes reflecting vaccine reaction (ie, misclassification) or flight surgeon recall of individuals restricted as a result of vaccine reaction (ie, recall bias) may have affected total vaccine-related DNIFs. Conversely, vaccine-associated events may be overestimated due to the temporal association when the diagnostic code reflected a probable nonvaccine DNIF but fell within a 12-day postvaccination time frame.

Table 1
US Air Force Air Mobility Command C-17 Aircrew Receiving Smallpox Vaccination* (n=678)

<table>
<thead>
<tr>
<th>Month</th>
<th>Study Site</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Base 1</td>
</tr>
<tr>
<td>Jan</td>
<td>9</td>
</tr>
<tr>
<td>Feb</td>
<td>19</td>
</tr>
<tr>
<td>Mar</td>
<td>17</td>
</tr>
<tr>
<td>Apr</td>
<td>6</td>
</tr>
<tr>
<td>May</td>
<td>3</td>
</tr>
<tr>
<td>Total</td>
<td>54</td>
</tr>
</tbody>
</table>

Table 2
Duty Restriction Events in US Air Force Air Mobility Command C-17 Aircrew After Receiving Smallpox Vaccination (n=678)

<table>
<thead>
<tr>
<th>Study Site</th>
<th>Duty Restriction Events*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Vaccine-</td>
</tr>
<tr>
<td></td>
<td>Attributed</td>
</tr>
<tr>
<td>Base 1 (n=54)</td>
<td>0</td>
</tr>
<tr>
<td>Base 2 (n=227)</td>
<td>0</td>
</tr>
<tr>
<td>Base 3 (n=397)</td>
<td>4</td>
</tr>
<tr>
<td>Total</td>
<td>4</td>
</tr>
</tbody>
</table>

* Duty restriction events were measured in terms of aircrew receiving a status of “duties not to include flying.”
Table 3
Summary and Statistical Comparison of US Air Force Air Mobility Command Duty Restriction Events Before and After Smallpox Vaccination*

<table>
<thead>
<tr>
<th>Month</th>
<th>2002 n</th>
<th>2002 DNIFs (%)</th>
<th>2003 n</th>
<th>2003 DNIFs (%)</th>
<th>Difference</th>
<th>Z Scores</th>
<th>P Value</th>
<th>95% CI</th>
<th>β</th>
<th>Sample Size Required†</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Base 1</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jan</td>
<td>677</td>
<td>139 (20.5)</td>
<td>700</td>
<td>150 (21.4)</td>
<td>0.009</td>
<td>0.408</td>
<td>.342</td>
<td>−0.034-0.052</td>
<td>.108</td>
<td>25,294</td>
</tr>
<tr>
<td>Feb</td>
<td>687</td>
<td>123 (17.9)</td>
<td>705</td>
<td>149 (21.1)</td>
<td>0.032</td>
<td>1.520</td>
<td>.064</td>
<td>−0.009-0.074</td>
<td>.451</td>
<td>1861</td>
</tr>
<tr>
<td>Mar</td>
<td>687</td>
<td>148 (21.5)</td>
<td>705</td>
<td>150 (21.3)</td>
<td>−0.003</td>
<td>−0.121</td>
<td>.548</td>
<td>−0.046-0.041</td>
<td>.064</td>
<td>308,533</td>
</tr>
<tr>
<td>Apr</td>
<td>689</td>
<td>134 (19.5)</td>
<td>708</td>
<td>137 (19.4)</td>
<td>−0.001</td>
<td>−0.046</td>
<td>.519</td>
<td>−0.043-0.041</td>
<td>.055</td>
<td>1,931,954</td>
</tr>
<tr>
<td>May</td>
<td>698</td>
<td>133 (19.1)</td>
<td>704</td>
<td>86 (12.2)</td>
<td>−0.068</td>
<td>−3.540</td>
<td>&lt;1</td>
<td>−0.106-0.031</td>
<td>.971</td>
<td>346</td>
</tr>
<tr>
<td><strong>Average</strong></td>
<td>688</td>
<td>135 (19.7)</td>
<td>704</td>
<td>134 (19.1)</td>
<td>−0.006</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td><strong>Base 2</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jan</td>
<td>477</td>
<td>54 (11.3)</td>
<td>510</td>
<td>23 (4.5)</td>
<td>−0.068</td>
<td>−4.015</td>
<td>&lt;1</td>
<td>−0.101-0.035</td>
<td>.992</td>
<td>185</td>
</tr>
<tr>
<td>Feb</td>
<td>484</td>
<td>37 (7.6)</td>
<td>524</td>
<td>41 (7.8)</td>
<td>0.002</td>
<td>0.107</td>
<td>.458</td>
<td>−0.031-0.035</td>
<td>.361</td>
<td>272,063</td>
</tr>
<tr>
<td>Mar</td>
<td>485</td>
<td>22 (4.5)</td>
<td>537</td>
<td>36 (6.7)</td>
<td>0.022</td>
<td>1.500</td>
<td>.068</td>
<td>−0.007-0.050</td>
<td>.446</td>
<td>1396</td>
</tr>
<tr>
<td>Apr</td>
<td>487</td>
<td>41 (8.4)</td>
<td>550</td>
<td>13 (2.4)</td>
<td>−0.061</td>
<td>−4.417</td>
<td>&lt;1</td>
<td>−0.088-0.034</td>
<td>.998</td>
<td>157</td>
</tr>
<tr>
<td>May</td>
<td>489</td>
<td>47 (9.6)</td>
<td>556</td>
<td>28 (5.0)</td>
<td>−0.046</td>
<td>−2.868</td>
<td>&lt;1</td>
<td>−0.077-0.015</td>
<td>.889</td>
<td>392</td>
</tr>
<tr>
<td><strong>Average</strong></td>
<td>484</td>
<td>40 (8.3)</td>
<td>535</td>
<td>28 (5.3)</td>
<td>−0.030</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td><strong>Base 3</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jan</td>
<td>430</td>
<td>54 (12.6)</td>
<td>412</td>
<td>64 (15.5)</td>
<td>0.030</td>
<td>1.243</td>
<td>.107</td>
<td>−0.017-0.077</td>
<td>.344</td>
<td>1690</td>
</tr>
<tr>
<td>Feb</td>
<td>433</td>
<td>43 (12.6)</td>
<td>418</td>
<td>60 (14.4)</td>
<td>0.044</td>
<td>1.980</td>
<td>.025*</td>
<td>&lt;0.001-0.088</td>
<td>.632</td>
<td>671</td>
</tr>
<tr>
<td>Mar</td>
<td>435</td>
<td>52 (12.0)</td>
<td>424</td>
<td>77 (18.2)</td>
<td>0.062</td>
<td>2.552</td>
<td>.005†</td>
<td>0.014-0.110</td>
<td>.819</td>
<td>407</td>
</tr>
<tr>
<td>Apr</td>
<td>429</td>
<td>62 (14.5)</td>
<td>431</td>
<td>56 (13.0)</td>
<td>−0.015</td>
<td>−0.621</td>
<td>.733</td>
<td>−0.061-0.032</td>
<td>.153</td>
<td>6870</td>
</tr>
<tr>
<td>May</td>
<td>424</td>
<td>57 (13.4)</td>
<td>427</td>
<td>60 (14.1)</td>
<td>0.006</td>
<td>0.257</td>
<td>.399</td>
<td>−0.040-0.053</td>
<td>.083</td>
<td>39,444</td>
</tr>
<tr>
<td><strong>Average</strong></td>
<td>430</td>
<td>54 (12.5)</td>
<td>422</td>
<td>63 (15.0)</td>
<td>0.026</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td><strong>Overall</strong></td>
<td>1602</td>
<td>131 (14.3)</td>
<td>1662</td>
<td>131 (13.6)</td>
<td>20.007</td>
<td>21.307</td>
<td>.904</td>
<td>20.018-0.004</td>
<td>.368</td>
<td>29,450</td>
</tr>
</tbody>
</table>

* Duty restriction rates, measured by DNIFs (duties not to include flying), were totaled in the control group (2002) and the study population (2003). The study population included 54 crew members from base 1 of the US Air Force Air Mobility Command, 397 from base 2, and 227 from base 3 who received the smallpox vaccination.
† Sample size required refers to the number of individuals in each population needed in order to conduct a test with \( P = .05 \) and \( \beta = .08 \).
‡ Statistically significant.

Abbreviation: NA, not available.
SPECIAL COMMUNICATION

trated educational campaign may have contributed to a decrease in subjective complaints due to expectations of common symptoms.23

Also, the study parameters assumed that, at most, only one potential DNIF was counted per subject per month. Review of the data revealed that few instances contradicting this assumption existed, occurring less than 10 times total among all DNIFs from all bases. Hence, the results would not be significantly affected. In addition, though the number of assigned aircrew did change month-to-month, the fluctuation was minimal during both the study and control periods. Turnover rates were low and aircrew at each base remained stable, thus minimizing variances attributable to changing monthly aircrew totals.

When comparing DNIF rates in the study population with SVP recipients, no consistent information exists. With only 54 study subjects (7.6%) receiving the vaccine at base 1, an increase in DNIF rates among the study population was not expected and did not occur. At base 3, where 227 study subjects (54.0%) received the vaccination, there was a statistically significant increase in DNIF totals compared with the preceding year.

At base 2, where DNIF rates were roughly one-third that of the other two bases, 397 study subjects (74.2%) received smallpox vaccinations, the largest percentage of the study cohort. At this base, the DNIF rate declined in 2003 compared with the preceding year. However, 48% of the smallpox vaccinations were administered during the month of February, which had the highest DNIF rate during the study period at base 2. The second highest rate at base 2 occurred in March, which corresponds to 83 smallpox vaccinations, the second highest total at that base.

Typically, DNIF rates differ from base to base as a result of Flight Medicine policies. Although all USAF flight surgeons are directed by Air Force Instruction 48-123 as a guide for determining DNIF conditions, such guidelines are subject to interpretation. In other words, individual flight surgeons may be more liberal or more strict in their interpretation of the guidelines. The intent of the Air Force Instruction is to ensure aircrew member safety, flight safety, and mission completion. Standard practices may vary from base to base, but each location practices the overall doctrine of medical flying status: to disqualify from flying those with conditions that may adversely affect flight safety.

The potential operational impact of the SVP was assessed by using the DNIF rates of sampled C-17 aircrews from AMC as a proxy measure of occupational hazard across the USAF. External validity to the entire USAF is hampered due to inevitable sampling. The “healthy worker effect” is germane in this case because aircrews are, by definition, healthy. They are also notorious for avoiding medical attention: aircrews and command are sensitive about reporting conditions that could negatively impact safety of flight, even though there is no disincentive for the individual flyer to report perceived minor symptoms. However, some generalizability is acceptable in that serious disease events with definitive diagnosis are difficult to mask.

Conclusions

An important issue to consider from the beginning of any public health initiative is safety. Benefits must outweigh risks. However, with pioneering adventures such as starting a vaccination program, such experiences must be recorded and scientifically dissected for others to follow. The SVP was not an occupational hazard or safety issue in this select cohort; it did not impose operational constraints on AMC aircrews as a result of adverse effects from vaccine-related DNIFs. Although the presented material has some real limitations, the overall safety of the program was successfully demonstrated and may serve as a reference for future occupational medicine and immunization programs.

The data presented in the current study may serve as an initial baseline for future smallpox vaccine recipients, especially in occupations with similar health standards and motivations (e.g., firefighters, emergency response crews, commercial pilots).26 Now that military medical studies have been shown to be generalizable with the US population as a whole to include non-military populations,26 this demonstration of safety should be more comparable from an occupational medicine perspective than it first may appear.

Acknowledgments

We thank Lt Col Mylene Huynh, MD, MPH, USAF, MC, FS, and Nap Hosang, MD, MPH, MBA, for their contributions to this work.

References


**JAOA call for case reports**

To advance the scholarly evolution of osteopathic medicine, JAOA—The Journal of the American Osteopathic Association invites osteopathic physicians, researchers, and others in the healthcare professions to submit case reports relevant to osteopathic medicine.

In preparing submissions, authors should adhere to the JAOA’s “Information for Contributors,” which is available at http://www.jaoa.org/misc/ifora.shtml.

For more information, authors can e-mail questions to jaoa@osteopathic.org.