Tetanus Immunity and Physician Compliance With Tetanus Prophylaxis Practices Among Emergency Department Patients Presenting With Wounds

David A. Talan, MD
Fredrick M. Abrahamian, DO
Gregory J. Moran, MD
William R. Mower, MD, PhD
Kumar Alagappan, MD
Brian R. Tiffany, MD, PhD
Charles V. Pollack, Jr., MA, MD
Mark T. Steele, MD
Lala M. Dunbar, MD, PhD
Mary D. Bajani, PhD
Robbin S. Weyant, PhD
Steven M. Ostroff, MD

Affiliations are provided at the end of this article.

See editorial, p. 315.

Study objective: We determine tetanus seroprotection rates and physician compliance with tetanus prophylaxis recommendations among patients presenting with wounds.

Methods: A prospective observational study of patients aged 18 years or older who presented to 5 university-affiliated emergency departments (EDs) because of wounds was conducted between March 1999 and August 2000. Serum antitoxin levels were measured by enzyme immunoassay with seroprotection defined as more than 0.15 IU/mL. Seroprotection rates, risk factors for lack of seroprotection, and rates of physician compliance with tetanus prophylaxis recommendations by the Advisory Committee on Immunization Practices were determined.

Results: The seroprotection rate among 1,988 patients was 90.2% (95% confidence interval 88.8% to 91.5%). Groups with significantly lower seroprotection rates were persons aged 70 years or older, 59.5% (risk ratio [RR] 5.2); immigrants from outside North America or Western Europe, 75.3% (RR 3.7); persons with a history of inadequate immunization, 86.3% (RR 2.9); and persons without education beyond grade school, 76.5% (RR 2.5). Despite a history of adequate immunization, 18% of immigrants lacked seroprotection. Overall, 60.9% of patients required tetanus immunization, of whom 57.6% did not receive indicated immunization. Among patients with tetanus-prone wounds, appropriate prophylaxis (ie, tetanus immunoglobulin and toxoid) was provided to none of 504 patients who gave a history of inadequate primary immunization (of whom 15.1% had nonprotective antibody titers) and to 218 (79%) of 276 patients who required only a toxoid booster.

Conclusion: Although seroprotection rates are generally high in the United States, the risk of tetanus persists in the elderly, immigrants, and persons without education beyond grade school. There is substantial underimmunization in the ED (particularly with regard to use of tetanus immunoglobulin), leaving many patients, especially those from high-risk groups, unprotected. Better awareness of tetanus prophylaxis recommendations is necessary, and future tetanus prophylaxis recommendations may be more effective if they are also based on demographic risk factors.

[*Ann Emerg Med.* 2004;43:305-314.]

0196-0644/$30.00

doi:10.1016/j.annemergmed.2003.09.017

Capsule Summary

What is already known on this topic

The importance of tetanus immunization is well known. However, there is little information on the percentage of patients presenting to the emergency department (ED) with wounds who are actually seroprotected against tetanus or how well emergency physicians comply with tetanus immunization guidelines.

What question this study addressed

The authors measured the tetanus antitoxin levels in 1,988 patients with wounds who presented to 5 affiliated EDs and assessed the compliance of emergency physicians with accepted tetanus immunization guidelines for these patients.

What this study adds to our knowledge

Ninety percent of patients had seroprotection. Patients older than 70 years, immigrants from outside of North America and Western Europe, persons without education beyond grade school, and persons with a history of inadequate immunizations had the lowest incidence of seroprotection. Emergency physicians often did not follow the established guidelines, with more than half of the patients not receiving the indicated immunization.

How this might change clinical practice

This study serves as a wake-up call to all emergency physicians to be more vigilant in evaluating wound patients for tetanus seroprotection and to properly follow the guidelines for tetanus immunization in such patients.

INTRODUCTION

Background

Tetanus continues to occur in the United States despite the widespread availability of a safe and effective vaccine. Between 1995 and 1997, 124 cases were reported, with a case fatality rate of 11%, and it is believed there is significant underreporting.[1]

Clinical tetanus in the United States has predominantly been limited to the elderly who were born before childhood immunization became routine.[1,2] Previous seroprevalence studies have found high rates of underprotection among the elderly and immigrants.[3,4] However, no seroprevalence data exist among emergency department (ED) patients seeking wound care. Recently, however, the epidemiology of tetanus has shifted to younger populations that include parenteral drug users.[1,2,5] Seroprotection rates among these patients, who often seek ED care, are also unknown.

Many patients seeking wound care have not received adequate tetanus immunizations.[6] In this circumstance, tetanus can be potentially prevented by episodic administration of tetanus toxoid either alone or with tetanus immunoglobulin, as dictated by recommendations of the Advisory Committee on Immunization Practices (Appendix).[7] However, to the best of our knowledge, no information exists about the extent to which these recommendations are followed in ED practice.

Importance

To evaluate the effectiveness of current tetanus prophylaxis recommendations, it is important to establish an understanding of the degree of tetanus risk among ED patients presenting with wounds and the extent to which episodic tetanus prophylaxis is appropriately administered.

Goals of This Investigation

The purpose of this study was to determine tetanus antitoxin levels among ED patients treated for wounds. We also evaluated physician compliance with Advisory Committee on Immunization Practices immunization recommendations for these patients and examined the frequency with which patients who did not receive adequate prophylaxis were unprotected based on their serology. We hypothesized that there continue to exist at-risk groups with substantial underprotection and practices that result in substantial underimmunization.

METHODS

Study Design and Setting

This was a prospective observational case series conducted at 5 urban university-affiliated EDs in collaboration with the US Centers for Disease Control and Prevention (CDC) and *EMERGE*ncy ID NET, a CDC-supported, ED-based network that conducts research on emerging infectious diseases. Each investigative site's institutional review board approved the study.

Selection of Participants

Patients selected were a convenience sample aged 18 years or older and presenting for wound-related complaints between March 1999 and August 2000. Patients were excluded if they were treated by an investigator, had been previously enrolled, or were unwilling or unable to follow up or provide informed consent.

Data Collection and Processing

Most patients were cared for by house staff who were supervised by attending emergency physicians. To prevent knowledge of the study's purpose from influencing

physicians' actions, the study was described as an investigation of the association of patient immunity with the development of wound-related infections and was called the Care of Wounds Study, or COWS. After the study was concluded, attending physicians were surveyed about knowledge of the study's intent.

Patients were evaluated on day 0 and received routine care as dictated by their treating physician. Treating physicians completed a standardized data form, recording wound characteristics, including location, depth, contamination, and type (ie, crush, puncture) with descriptors for tetanus-prone wounds used in Advisory Committee on Immunization Practices recommendations.[7] Other data, such as whether antimicrobials were prescribed and the presence of diabetes or any immune system problem, including cancer (receiving current treatment) and HIV infection, were also collected to distract physicians from the study's purpose. All patients had serum collected for measurement of baseline tetanus antitoxin level.

All patients were asked to return for follow-up care at days 5 to 7. A research associate recorded information on a standardized form about past tetanus immunizations, including the timing and completeness of primary and booster immunizations. Responses were recorded as "received," "did not receive," and "did not know." At this time, to evaluate an anamnestic response to tetanus toxoid, a second serum specimen was collected from patients who had received tetanus toxoid but not tetanus immunoglobulin. Those patients who, according to the immunization history, should have received tetanus toxoid, tetanus immunoglobulin, or both on their day 0 visit but did not were given immunization according to Advisory Committee on Immunization Practices recommendations (Appendix). Patients who were given only toxoid at this visit returned in 5 to 7 days for another antitoxin specimen. Patients who did not return for follow-up after day 0 were contacted by telephone to obtain their immunization history. Research associates also reviewed ED charts from day 0 to determine whether there was sufficient documentation of the time since the patient's last tetanus booster and whether the patient had completed a primary immunization series.

Methods of Measurement

Serum specimens were spun and frozen at –30°C (–86.0°F) at the investigative sites and shipped to the CDC Meningitis and Special Pathogens Branch for paired testing. Antitoxin levels were determined by enzyme immunoassay (Bindazyme Anti-Tetanus Toxoid IgG Enzyme Immunoassay Kit; The Binding Site Ltd, San Diego, CA) according to manufacturer's recommendations. Each patient's antibody level was calculated as the average of the results of 2 assays (κ correlation coefficient 0.98). Persons conducting the assays were unaware of patient identifiers, clinical information, and the study's purpose.

Outcome Measures

A protective antitoxin level was defined as 0.15 IU/mL or greater; only baseline values were used to calculate seroprotection rates. The accuracy and validity of this assay and cutoff level as a threshold for protection have been addressed previously.[3,4,8-10]

Physician compliance with 1991 Advisory Committee on Immunization Practices tetanus prophylaxis recommendations (Appendix) was based on wound data collected on day 0 and immunization history subsequently collected by the research associate. Tetanus toxoid and immunoglobulin were fully available at the study sites during the study period. Primary immunization was defined as at least 3 previous doses of tetanus toxoid. Tetanus-prone wounds were defined as those that had characteristics recorded by the treating physician that were tetanus prone according to Advisory Committee on Immunization Practices recommendations (ie, those "contaminated with dirt, feces, soil, or saliva; puncture wounds; avulsions; and wounds resulting from missiles, crushing, burns or frostbite").[7] Other types of wounds were considered non–tetanus prone. Only patients stating that they received primary or booster immunizations consistent with Advisory Committee on Immunization Practices recommendations were considered to have adequate immunization.

Primary Data Analysis

Data were summarized with simple descriptive statistics. Frequencies were bounded by 95% confidence intervals (CIs). Risk ratios (RRs) were calculated for variables shown in previous studies to be associated with lack of tetanus seroprotection (lack of immunization, age >70 years, immigration, limited education, and intravenous drug use).[3,4] Attributable risk was calculated for each of these risk factors to determine the degree to which the presence or absence of the factor accounted for the variation in seroprotection rates. Statistical calculations were completed using STATA software (version 5, Stata Corporation, College Station, TX).

RESULTS

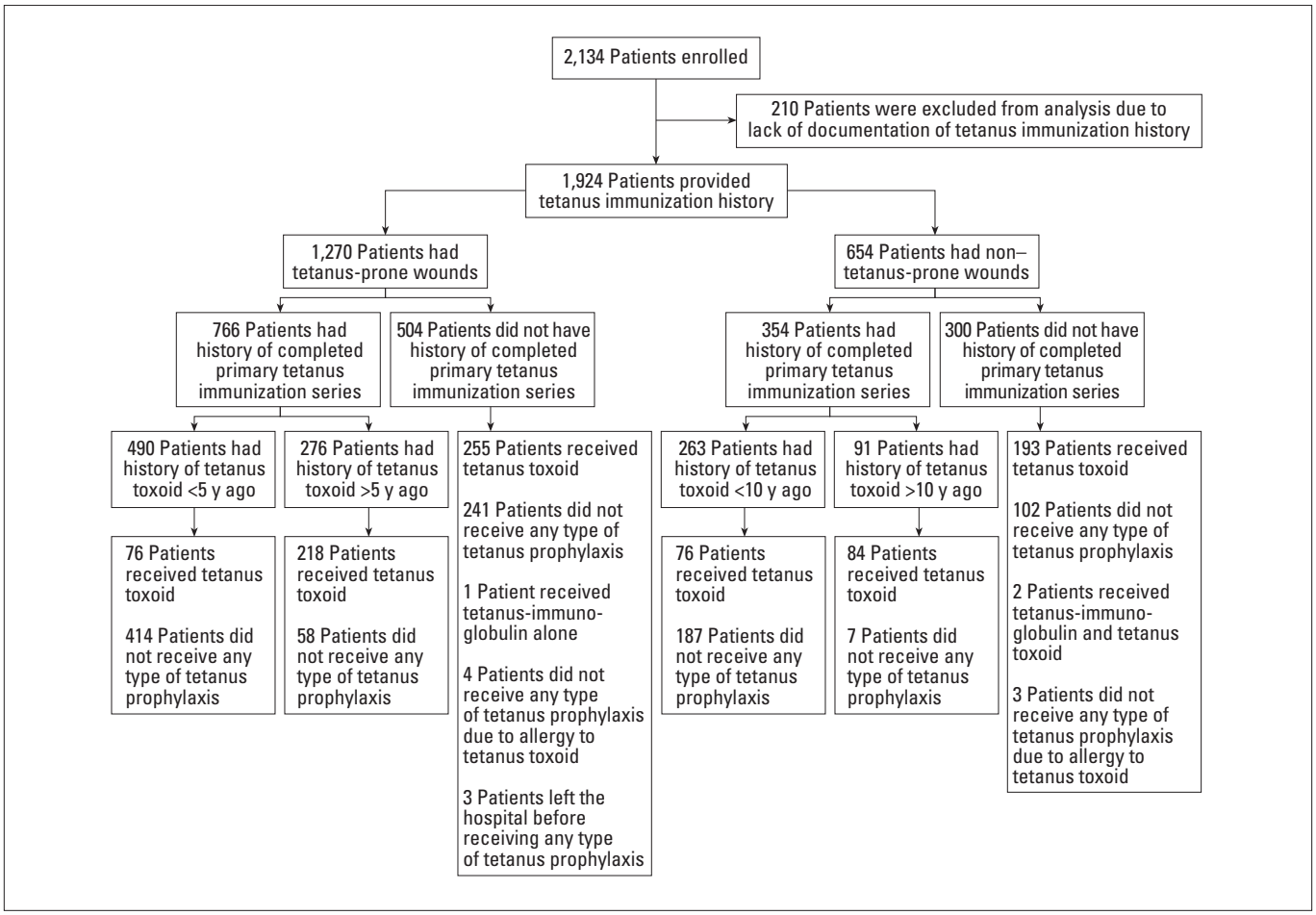
Among 2,134 patients enrolled, 146 (6.8%) were excluded from serology evaluation because of a lack of specimen, and 210 (9.8%) were excluded from evaluation of tetanus immunization because their accompanying data sheet lacked documentation of tetanus immunization history (Figure). Twenty-three attending physicians completed a survey after the completion of the study to determine their knowledge of the study's purpose. Most had either no idea (52%) or low certainty (48%) of the study's specific intent, with only 12% indicating evaluation of tetanus prophylaxis as the study's possible purpose.

The ages of 1,988 patients who had baseline sera collected ranged from 18 to 90 years (median 37 years), and 68.2% were men. The host and wound characteristics of the study population are summarized in Table 1.

Overall, the tetanus seroprotection rate among 1,988 patients was 90.2% (95% CI 88.8% to 91.5%). Seroprotection rates among various groups are summarized in Table 2. The following patient characteristics were associated with lack of seroprotection: aged 70 years or older; attending grade school outside the United States; immigration from outside North America or Western Europe; education not beyond grade school; Hispanic ethnicity; and female sex. Parenteral drug use was not associated with lack of seroprotection (RR 0.2; 95% CI 0.1 to 0.6).

A history of inadequate primary immunization or booster within 10 years was associated with lack of seroprotection versus those with a history of adequate immunization (Table 2). Most patients (67.7%) classified as inadequately immunized stated that they did not know their immunization status (as opposed to those who knew they were inadequately immunized), and

Figure.
Distribution of wound types, immunization status, and treatment.



this history was also associated with lack of seroprotection (83.9%; 95% CI 81.1% to 86.3%; RR 4.5, 95% CI 3.1 to 6.6).

The following factors were found to account for the variation in seroprotection rates: history of inadequate immunization (attributable risk 84%), aged 70 years or older (attributable risk 81%), immigration (attributable risk 67%), and education not beyond grade school (attributable risk 59%). Notably, even among patients providing a history of adequate immunization, immigration was strongly associated with lack of seroprotection (82.1% versus 98.2% among nonimmigrants; RR 10.0; 95% CI 5.1 to 19.5). For example, 18% of such persons born outside North America or Western Europe

Table 1.
The host and wound characteristics of the study population.[*]

Characteristic	No. (%) (n=2,134)
Host	
Diabetic	175 (8.2)
Injection drug use	206 (9.7)
Steroids	16 (0.7)
Normal	1,762 (82.6)
Site	
Head/neck	506 (23.7)
Trunk	141 (6.6)
Perineum	39 (1.8)
Hand	604 (28.3)
Foot	193 (9.0)
Arm	362 (17.0)
Leg	348 (16.3)
Type	
Laceration	993 (46.5)
Abrasion	287 (13.4)
Puncture	181 (8.5)
Injection	113 (5.3)
Gunshot wounds	23 (1.1)
Crush	57 (2.7)
Avulsion	53 (2.5)
Bite	163 (7.6)
Burn/frostbite	55 (2.6)
Postoperative	23 (1.1)
Ulcer	94 (4.4)
Woundless infection	156 (7.3)
Abscess	78 (3.7)
No information	16 (0.7)
Other	11 (0.5)
Depth	
Superficial	566 (26.5)
Subcutaneous	754 (35.3)
Fascia/tendon	120 (5.6)
Bone/joint	55 (2.6)
Infected	
Yes	638 (29.9)
No	1,496 (70.1)
Infection type	
Abscess	307 (14.4)
Cellulitis	370 (17.3)
Thrombophlebitis	6 (0.3)
Unknown	2 (0.1)
Time since injury	
<6 h	898 (42.1)
6–12 h	218 (10.2)
13–24 h	137 (6.4)
>24 h	241 (11.3)
Unknown	2 (0.1)

[*]The characteristics within each category may not add up to 100% because of some patients having >1 characteristic.

Table 2.
Prevalence of protective tetanus antitoxin levels among US ED patients with wounds, 1998-2000.

Group	No. With Protective Tetanus Antitoxin Levels/ No. Tested	Seroprotection Rate, % (95% CI)	RR (95% CI)[*]
Age, y			
18–29	544/573	94.9 (92.8–96.6)	
30–39	507/533	95.1 (92.9–96.8)	
40–49	396/426	93.0 (90.1–95.2)	
50–59	189/211	89.6 (84.6–93.3)	
60–69	82/111	73.9 (64.7–81.8)	
≥70	75/126	59.5 (50.4–68.2)	5.2 (4.0–6.8)
Sex			
Male	1,249/1,355	92.2 (90.6–93.6)	
Female	543/632	85.9 (83.0–88.5)	1.8 (1.4–2.4)
Place of birth			
North America/ Western Europe[†]	1,344/1,439	93.4 (92.0–94.6)	
Mexico/Central America/ South America[†]	195/259	75.3 (69.6–80.4)	3.7 (2.9–4.9)
Race			
White (non-Hispanic)	630/702	89.7 (87.3–91.9)	
Black (non-Hispanic)	557/573	97.2 (95.5–98.4)	
Hispanic	394/475	82.9 (79.3–86.2)	2.2 (1.7–2.9)
Education level			
Elementary	78/102	76.5 (67.0–84.3)	2.5 (1.7–3.6)
Junior high school	203/235	86.4 (81.3–90.5)	
High school	989/1,076	91.9 (90.1–93.5)	
College	321/362	88.7 (84.9–91.7)	
Attended US elementary school			
Yes	1,375/1,472	93.4 (92.0–94.6)	
No	239/327	73.1 (67.9–77.8)	4.1 (3.1–5.3)
Served in US military			
Yes	166/179	92.7 (87.9–96.1)	
No	1,448/1,620	89.4 (87.8–90.8)	
Served in foreign military			
Yes	29/40	72.5 (56.1–85.4)	
No	1,585/1,759	90.1 (88.6–91.5)	
Parenteral drug use			
Yes	134/137	97.8 (93.7–99.5)	
No	1,489/1,673	89.0 (87.4–90.5)	
History of adequate immunization[‡]			
Yes	664/697	95.3 (93.4–96.7)	
No	957/1,109	86.3 (84.1–88.3)	2.9 (2.0–4.2)

[*]RRs for lack of seroprotection listed only for factors in which lower CIs were >1.
[†]North America, n=1,407; Western Europe, n=32; Mexico, n=203; Central America, n=32; South America, n=24.
[‡]Adequate primary immunization and a tetanus toxoid booster according to Advisory Committee on Immunization Practices guidelines.

lacked seroprotection. There were too few patients to evaluate this phenomenon in elderly patients.

Of 940 patients who received only tetanus toxoid, 604 (64.3%) patients had serum specimens for tetanus antitoxin assay taken at day 0 and days 5 to 7. Forty-nine (8.1%) patients had nonprotective baseline titers, of whom 16 (32.7%) demonstrated a protective titer at days 5 to 7 (ie, an anamnestic response); 1 (8.3%) of 12 patients aged 70 years or older had an amnestic response. A history of primary immunization was present in 62.5% of patients with an anamnestic response and 24.2% of patients without one. An anamnestic response was observed in 3 (37.5%) of 8 patients who had repeated specimens taken on days 2 to 4 and 6 (35.3%) of 17 who returned on days 8 to 17.

Immunization history was provided by 1,924 patients, of whom 1,806 (93.9%) had baseline tetanus antitoxin levels measured. Of 1,171 (60.9%) patients who were underimmunized according to medical history and required some form of tetanus prophylaxis, 674 (57.6%) patients did not receive indicated immunization in the ED (Figure). Seroprotection rates among patients reported by whether their immunizations were up to date according to Advisory Committee on Immunization Practices recommendations and wound type are summarized in Table 3.

Of 1,270 patients with tetanus-prone wounds, 504 (39.7%) stated that they had not completed the primary immunization series; none of these individuals received appropriate prophylaxis (ie, tetanus immunoglobulin and toxoid). Baseline tetanus antitoxin serology was obtained from 469 of these patients, of whom 71 (15.1%) had a nonprotective titer (39.3% of persons aged ≥70 years and 28.0% of immigrants).

Of 766 patients with tetanus-prone wounds who had received primary immunization, 276 (36.0%) stated that they had not been given tetanus toxoid within 5 years. Among these patients, 218 (79.0%) were appropriately given a booster immunization. The remaining 58 (21.0%) patients received neither a booster nor tetanus immunoglobulin. Of these, 55 patients had baseline tetanus antitoxin serology and 5 (9.1%) patients had a nonprotective titer. Seventy-six (15.5%) of 490 patients who had a history of completing the primary immunization series and receiving toxoid within 5 years were inappropriately given a booster.

Of 654 patients who presented with non–tetanus-prone wounds, 300 (45.9%) stated they had not completed the primary immunization series. Of these 300 patients, 193 (64.3%) were appropriately given tetanus toxoid. Of 91 patients who had a history of having completed the primary immunization but not having received tetanus toxoid within 10 years, 84 (92.3%) were appropriately given tetanus toxoid. Among 263 patients who had a history of completing the primary immunization series and receiving toxoid within the previous 10 years, 76 (28.9%) were inappropriately given a booster (15.3% of those who stated they received a booster within 5 years and 81.5% of those who received one between 5 and 10 years).

Therefore, of 1,924 total patients, 1,096 (57.0%) patients were treated appropriately according to Advisory Committee on Immunization Practices recommendations, 674 (35.0%) patients did not receive indicated prophylaxis, 152 (7.9%) patients received tetanus toxoid unnecessarily, and 2 (0.1%) patients received tetanus immunoglobulin unnecessarily.

Review of the ED medical records revealed adequate documentation of primary immunization history in 418 (19.6%) cases and time since last tetanus booster in 1,369 (64.2%) cases.

Table 3.
Prevalence of protective tetanus antitoxin levels among US ED patients with wounds, 1999-2000, by immunization history and wound type.

	Adequacy of Tetanus Immunization*			
	Up to Date		Not Up to Date	
Tetanus Antitoxin Levels	Protective, No. (%)	Not Protective, No. (%)	Protective, No. (%)	Not Protective, No. (%)
All wounds	664 (95.3)	33 (4.7)	957 (86.3)	152 (13.7)
Tetanus-prone wounds	427 (94.7)	24 (5.3)	645 (88.2)	86 (11.8)
Non–tetanus prone	237 (96.3)	9 (3.7)	312 (82.5)	66 (17.5)

*According to patient history and 1991 Advisory Committee on Immunization Practices tetanus prophylaxis recommendations.[7]

LIMITATIONS

In this study, compliance with Advisory Committee on Immunization Practices recommendations was used as the criterion standard for judging the appropriateness of tetanus prophylaxis practices. However, these recommendations have not been validated as the optimally effective strategy. The number of reported tetanus cases in the United States presently is low compared with that observed before the institution of routine and episodic

immunization policies. It is beyond the scope of this research to comment on the cost benefit of current use or improved compliance with tetanus wound prophylaxis recommendations, which may change with aging of the population and immigration trends from underdeveloped areas. Perhaps future strategies will be more targeted to high-risk groups and use information systems for better access to patient immunization data.

Practices at teaching institutions may not reflect those at other settings. The results of this study may not be generalizable to the population at large. We chose to study patients presenting to EDs for wound care because high-risk patients such as immigrants and the underinsured tend to seek care in this setting. Also, one would expect that wounds of ED patients would be more likely to be tetanus prone than those of patients treated in office settings. In addition, it is possible that physician practice may have inadvertently been affected by knowledge of the study, even though our postinvestigation survey suggested otherwise.

Patients may have given physicians a different history of immunization than was later given to the research associates; however, asking the physician to record these data would have potentially confounded our ability to observe physicians' natural behavior. Our medical record audit also revealed infrequent documentation of tetanus history; however, charting is typically incomplete, and even with affirmative documentation, it is often ambiguous. Immunization history may not reflect actual immunization, although this is the information available to caregivers making prophylaxis decisions. Tetanus antitoxin levels are a surrogate for completeness of past immunization and actual protection, which cannot be tested directly. Although seroprotection rates would be somewhat higher if the anamnestic response were considered, a bias may exist in this subpopulation who were given tetanus toxoid and returned for follow-up.

DISCUSSION

A 1995 editorial commenting on the low rates of tetanus seroprotection and continued observation of tetanus cases in the United States stated that "a case of tetanus reflects the failure of our health care delivery system to provide immunization."[11] Previous studies have found that approximately 30% of persons older than 6 years lack protective tetanus immunity, with rates as high as 60% among Mexican-born Americans and the elderly.[3,4] Not surprisingly, past tetanus cases and tetanus-related deaths occurred predominantly among the elderly.[1,2] However, for cases reported between 1995 and 1997, patients aged 20 to 50 years accounted for a greater proportion of cases than older patients.[1] Several of these cases occurred in parenteral drug users, many of whom were Hispanic.[5]

This study evaluated current tetanus seroprotection rates among ED patients seeking wound care, including patients from various apparent tetanus risk groups such as parenteral drug users. Because it has not been clear from past studies the extent to which patients with "nonprotective" titers produce a rapid and potentially protective anamnestic response when given tetanus toxoid (or when exposed to natural toxin), especially among previously immunized patients, a subsequent specimen was collected for serologic analysis in the subgroup of patients who received only tetanus toxoid. We also examined the extent to which immunization practices complied with Advisory Committee on Immunization Practices recommendations. To our knowledge, our study is the first to examine the relationship of immunization practices with need according to tetanus antitoxin levels in individual patients.

We found that many more people are underimmunized according to their history (60.9%) than in fact are unprotected according to serum antitoxin levels (9.8%). Consistent with other seroprevalence studies conducted in the general US population, we found that among young adult North Americans and Western Europeans seeking wound care in the ED, approximately 90% had protective tetanus antibody titers. However, certain subpopulations continue to be relatively underprotected, specifically the elderly, immigrants, and persons with education limited to grade school. Although seroprotection is associated with the patient's recall of past immunization, demographic factors also seem to be important. For example, approximately 18% of persons born outside North America and Western Europe who stated they had received primary immunization and a booster within 10 years lacked seroprotection. Despite the recent observation of parenteral drug users composing a new risk group among tetanus cases reported to the CDC, parenteral drug use was not associated with lack of seroprotection in our study of more than 130 such cases.[1,2,5] Tetanus in these individuals may be due to increased exposure to *Clostridium* spores through drug use and infection.

Compliance with Advisory Committee on Immunization Practices immunization recommendations was poor. Despite this poor compliance, because of the high

overall rate of seroprotection, lack of seroprotection among patients who received inadequate prophylaxis was uncommon. Among the patients at greatest risk, those with tetanus-prone wounds and lacking primary immunization, none received recommended prophylaxis in the ED. Of these patients, 15.1% had nonprotective tetanus antitoxin titers, with substantially higher rates among the elderly (39.3%) and immigrants (28.0%).

Most patients with baseline "nonprotective" tetanus antitoxin titers did not develop an anamnestic response when given toxoid. In approximately one third of these individuals, toxoid boosted titers into what is considered protective range within 7 days, the earlier end of the disease incubation period. Lack of an anamnestic response was related to inadequate primary immunization and advanced age. Persons older than 70 years had an anamnestic response rate of only 8.3%. For patients with tetanus-prone wounds, these observations emphasize the need to give tetanus immunoglobulin in addition to toxoid to persons lacking primary immunization and consideration of its use in the elderly, regardless of immunization history. Note that Alagappan et al[12] found an 86% response rate 2 months after tetanus toxoid among geriatric patients with baseline nonprotective tetanus antitoxin titers. Whether the elderly lack or have a delayed anamnestic response and whether this is due to lack of previous immunizations or immunosenescence is unclear and requires further study.

Physicians provided inadequate prophylaxis to approximately 35% of patients with wounds. For patients with tetanus-prone wounds who did not recall having received primary immunization, tetanus immunoglobulin and tetanus toxoid were never administered. Tetanus immunoglobulin is a human product that is considered safe, with no reported cases of transmission of infection. Tetanus immunoglobulin provides immediate protection that lasts 3 weeks, throughout the duration of the disease incubation period. In light of the recent shortage of tetanus toxoid,[13] tetanus immunoglobulin would be an alternative to toxoid for episodic prophylaxis of tetanus-prone wounds in patients who required only a booster. Because the patient history of completion of the primary immunization series (ie, ≥3 previous toxoid injections) was infrequently recorded, we suspect that there is a lack of appreciation of the importance of this information by physicians and that this datum is not routinely collected as part of nursing triage assessments.

Twenty-one percent of patients with tetanus-prone wounds who required only a booster did not receive it. Many physicians may not be aware that tetanus-prone wounds require a booster to be given if more than 5 years have elapsed since the last immunization, as opposed to 10 years for low-risk wounds. The overall poor compliance with Advisory Committee on Immunization Practices tetanus recommendations is surprising because these have been in place for many years and have been endorsed by various professional societies, including the American College of Emergency Physicians.[14]

In 1975, Brand et al[6] reported that 27% of ED patients with tetanus-prone wounds were incompletely immunized. These results probably underestimate the rate of underimmunization because treating physicians in this study were not blinded to the study's intent. Looked at another way, among reported patients with tetanus between 1995 and 1997 who sought antecedent medical care, only 39% received tetanus toxoid, and 23% received tetanus immunoglobulin when these were indicated.[1] Like Brand et al,[6] we found that about 10% of patients were overimmunized.

In retrospect, to ensure that physicians' behavior was not affected by knowledge of the study's purpose, we would have done a more complete survey of all participating physicians, both attendings and residents. If there was some awareness of the study, then our results may be an overestimate of actual rates of compliance with tetanus prophylaxis recommendations.

We also measured the anamnestic response 5 to 7 days after toxoid administration.However, had we had the resources, it would have been ideal to evaluate tetanus antitoxin levels over a 3-week period, the full range of the tetanus incubation period.

In summary, although tetanus seroprotection rates are generally high, many persons in the United States, particularly the elderly, immigrants, and persons with education limited to grade school, continue to be at risk. Despite a history of adequate immunization, many immigrants with wounds appear to lack protection against tetanus. Until preventive care can reach these groups, tetanus protection will have to be achieved by episodic immunization when patients present with wounds. According to current tetanus prophylaxis recommendations, there is substantial underimmunization in the ED. Barriers to compliance need to be investigated. Future tetanus wound prophylaxis may be enhanced by better health care provider education and standardized management protocols. In addition, future tetanus prophylaxis recommendations may be more effective if they are based on demographic risk factors in addition to patient immunization history and wound characteristics.

From the Department of Medicine, Divisions of Emergency Medicine and Infectious Diseases, Olive View–University of California–Los Angeles Medical Center, Sylmar, CA (Talan, Abrahamian, Moran); the Emergency Medicine Center, University of California–Los Angeles Medical Center, Los Angeles, CA (Mower); the Department of Emergency Medicine, Long Island Jewish Medical Center, New Hyde Park Island, NY (Alagappan); the Department of Emergency Medicine, Maricopa Medical Center, Phoenix, AZ (Tiffany, Pollack); the Department of Emergency Medicine, Truman Medical Center, University of Missouri–Kansas City, Kansas City, MO (Steele); the Department of Emergency Medicine, Charity Medical Center, Louisiana State University, New Orleans, LA (Dunbar); National Center for Infectious Diseases, Centers for Disease Control and Prevention, Atlanta, GA (Bajani, Weyant, Ostroff).

Dr. Pollack is currently affiliated with the Pennsylvania Hospital, University of Pennsylvania Health System, Philadelphia, PA.

We wish to acknowledge Stewart Geboff, Gina Pulido, John DeHart, Chris King, the study assistants, and medical and nursing staff at the participating centers for their assistance with this project.

Author contributions: DAT, GJM, KA, BRT, CVP, MTS, LMD, RSW, and SMO conceived and designed the study. FMA, KA, BRT, CVP, MTS, and LMD acquired the data. WRM, DAT, and FMA analyzed and interpreted the data. DAT and FMA drafted the manuscript. WRM and FMA conducted the statistical analysis. MDB conducted the serologic testing. DAT obtained funding. DAT, KA, BRT, CVP, MTS, LMD, RSW, and SMO provided administrative, technical, and material support. DAT, FMA, KA, BRT, CVP, MTS and LMD supervised the study. All authors take responsibility for the paper as a whole.

Received for publication June 26, 2003. Revisions received August 28, 2003, and September 19, 2003. Accepted for publication September 24, 2003.

Supported by a research grant from Bayer Biological Products, Research Triangle Park, NC.

Dr. Talan, Dr. Abrahamian, Dr. Moran, and Dr. Alagappan have received speaking honoraria and research grants from Bayer. Dr. Dunbar has received research grants from Bayer.

Reprints not available from the authors.

Address for correspondence: David A. Talan, MD, Olive View–University of California–Los Angeles Medical Center, 14445 Olive View Drive, North Annex, Sylmar, CA 91342; 818-364-3107; fax 818-364-3268; E-mail idnet@ucla.edu.

REFERENCES

1. Centers for Disease Control and Prevention. Tetanus surveillance: United States, 1995-1997. *MMWR Morb Mortal Wkly Rep.* 1998;47:1-13.
2. Centers for Disease Control and Prevention. Tetanus surveillance: United States, 1998-2000. *MMWR Morb Mortal Wkly Rep.* 2003;52:1-8.
3. Gergen PJ, McQuillan GM, Kiely M, et al. A population-based serologic survey of immunity to tetanus in the United States. *N Engl J Med.* 1995;332:761-766.
4. McQuillan GM, Kruszon-Moran D, Deforest A, et al. Serologic immunity to diphtheria and tetanus in the United States. *Ann Intern Med.* 2002;136:660-666.
5. Centers for Disease Control and Prevention. Tetanus among injecting-drug users: California, 1997. *MMWR Morb Mortal Wkly Rep.* 1998;47:149-151.
6. Brand DA, Acampora D, Gottlieb LD, et al. Adequacy of antitetanus prophylaxis in six hospital emergency rooms. *N Engl J Med.* 1983;309:636-640.
7. Immunization Practices Advisory Committee. Diphtheria, tetanus, and pertussis: recommendations for vaccine use and other preventive measures: recommendations of the Immunization Practices Advisory Committee (ACIP). *MMWR Morb Mortal Wkly Rep.* 1991;40:1-28.
8. McComb JA. The prophylactic dose of homologous tetanus antitoxin. *N Engl J Med.* 1964;270:175-178.
9. Simonsen O, Bentzon MW, Heron I. ELISA for the routine determination of antitoxic immunity to tetanus. *J Biol Stand.* 1986;14:231-239.
10. Melville-Smith ME, Seagroatt VA, Watkins JT. A comparison of enzyme-linked immunosorbent assay (ELISA) with the toxin neutralization test in mice as a method for the estimation of tetanus antitoxin in human sera. *J Biol Stand.* 1983;11:137-144.
11. Sanford JP. Tetanus: forgotten but not gone. *N Engl J Med.* 1995;332:812-813.
12. Alagappan K, Rennie W, Narang V, et al. Immunologic response to tetanus toxoid in geriatric patients. *Ann Emerg Med.* 1997;30:459-462.
13. Centers for Disease Control and Prevention. Notice to readers: shortage of tetanus and diphtheria toxoids. *MMWR Morb Mortal Wkly Rep.* 2000;49:1029-1030.
14. American College of Emergency Physicians. Tetanus immunization recommendations for persons seven years of age and older: American College of Emergency Physicians. *Ann Emerg Med.* 1986;15:1111-1112.

APPENDIX.

Summarized recommendations for the use of tetanus prophylaxis in routine wound management: Advisory Committee on Immunization Practices, 1991.[7]

	Clean, Minor Wounds		All Other Wounds*	
History of Adsorbed Tetanus Toxoid	**Td†**	**TIG**	**Td**	**TIG**
Unknown or <3 doses	Yes	No	Yes	Yes
≥3 Doses‡	No§	No	No‖	No

Td, Tetanus and diphtheria toxoids; **TIG,** tetanus immunoglobulin.

*Such as, but not limited to, wounds contaminated with dirt, feces, soil, or saliva; puncture wounds; avulsions; and wounds resulting from missiles, crushing, burns, or frostbite.

†For children aged <7 years, the diphtheria and tetanus toxoids and acellular pertussis vaccines (DTaP) or the diphtheria and tetanus toxoids and whole-cell pertussis vaccines (DTwP)—or pediatric diphtheria and tetanus toxoids (DT), if pertussis vaccine is contraindicated—are preferred to tetanus toxoid (TT) alone. For persons aged ≥7 years, the tetanus and diphtheria toxoids for adults is preferred to TT alone.

‡If only 3 doses of fluid toxoid have been received, a fourth dose of toxoid, preferably an adsorbed toxoid, should be administered.

§Yes, if >10 years have elapsed since the last dose.

‖Yes, if >5 years have elapsed since the last dose. More frequent boosters are not needed and can accentuate adverse effects.