Infections Complicating the Care of Combat Casualties During Operations Iraqi Freedom and Enduring Freedom

Clinton K. Murray, MD, Kenneth Wilkins, PhD, Nancy C. Molter, PhD, Fang Li, MS, Lily Yu, MS, Mary Ann Spott, MPH, MBA, Brian Eastridge, MD, Lorne H. Blackbourne, MD, and Duane R. Hospenthal, MD, PhD

Background: Continued assessment of casualty complications, such as infections, enables the development of evidence-based guidelines to mitigate excess morbidity and mortality. We examine the Joint Theater Trauma Registry (JTTR) for infections and potential risk factors, such as transfusions, among Iraq and Afghanistan trauma patients.

Methods: JTTR entries from deployment-related injuries with completed records between March 19, 2003, and April 13, 2009, were evaluated using International Classification of Diseases-9 codes for infections defined by anatomic/clinical syndromes and/or type of infecting organisms. Risk factors included mechanisms of injury, patient demographics, Injury Severity Score (ISS), and transfusion, including massive transfusions (>10 units of packed red blood cells).

Results: We reviewed 16,742 patients entries (15,021 from Operation Iraqi Freedom (9,883 battle injuries [BI]) and 1,721 from Operation Enduring Freedom (1,090 BI). A total of 96.6% were men and 77.6% were Army personnel. The majority of BI were due to explosive devices (36.3%). There were 921 patients (5.5%) who had one or more infection codes with only 111 (0.6%) recorded deaths (16 with infections). Infections were commonly gram-negative bacteria (47.6%) involving skin/wound infections (26.7%), and lung infections (14.6%). Risk factors or associations that were most notable in univariate and multivariate analysis were calendar year of trauma, ISS, and pattern of injury.

Conclusion: The 5.5% infection rate is consistent with previous military and civilian trauma literature; however, with the limitations of the JTTR, the infection rate is likely an underrepresentation due to inadequate level V and long-term infectious complications data. Combat operational trauma is primarily associated with gram-negative bacteria typically involving infections of wounds or other skin structures and lung infections such as pneumonia. They are commonly linked with higher ISS and injuries to the head, neck, and face.

Key Words: Combat, Infection, Afghanistan, War, Trauma registry.

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**Report Documentation Page**

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patients, risk factors included, and definitions of infection. Overall, many of the evidence-based clinical practice guidelines, including the infection specific guidelines, have limited level of evidence for the recommendations. This can substantially influence the quality of the recommendations.

Ongoing studies of infections in the combat zone are required to mitigate excess morbidity and mortality from combat-related injury infections. This study expands on the previous review of infections associated with trauma to include a larger population of JTTR entries, a broader array of risk factors, including transfusion data, and more complete records on the length of hospital and ICU length of stays, and days of mechanical ventilation. Injury patterns were grouped by anatomic distribution, which were determined by the presence of 1 or more non-zero ordinal scores specific to that body region within the Military Abbreviated Injury Scale (MAIS). MAIS body regions were grouped accordingly: head/neck, face, thorax, including injury to spine; abdomen, including injury to pelvic contents; extremity injury, whether upper or lower; and external injury, including burns and other trauma.

Infectious complications were captured using International Classification of Diseases (ICD)-9 codes entered within the JTTR. The infectious complications were bundled for analysis based upon major categories of anatomic/clinical syndromes, which included bacteremia, abdominal, bone/joint, skin, lung, urine, central nervous system and other. Infectious disease ICD-9 codes were also bundled into gram-positive bacteria, gram-negative bacteria, other bacteria, and fungi.

Statistical analysis included descriptive evaluation of various subgroups of the overall cohort, point, and interval estimates for standard logistic and Poisson regression coefficients within multivariate analyses, whereas univariate or bivariate analyses included the unpaired Student’s t test or Wilcoxon Mann-Whitney rank-sum test for continuous variables, and χ² or Fisher’s exact test for categorical variables where appropriate. A nominal 0.05 significance level was used throughout these analyses. Association analyses included logistic regression to yield estimates comparable with results from the previous review of available JTTR data, whereas the more complete set of records available for the current review allowed greater precision by adjusting for individual differences in length of posttrauma hospitalization. Multivariate analyses are expanded here to employ an outcome of counts of infectious complications, modeled with

### MATERIALS AND METHODS

The JTTR is a DoD performance improvement program that collects medical data from patients suffering combat- and noncombat-related trauma during military operations in Iraq and Afghanistan. The JTTR contains data that are collected and tabulated in a central repository database. Although some data are available from the point of injury, the majority of the data are collected at Level III (NATO Role 3) medical facilities, such as combat support hospitals, and through the various levels of medical care until reaching definitive medical care at US military treatment facilities. There has been an unavoidable lag in completion of records, which not only motivates our current analysis as an update to the previous review, but it also underscores the need to carefully consider how recent years’ data may be limited. This study was reviewed and approved by the Brooke Army Medical Center Institutional Review Board and the scientific review boards of the United States Army Institute of Surgical Research and the Infectious Disease Clinical Research Program.

This study assessed the JTTR for the presence of infections associated with trauma sustained during combat operations in Iraq and Afghanistan. Data recovery from the JTTR for use in this study included patients with completed records between March 19, 2003, and April 13, 2009. The data collected included summary totals of patients with data captured in the JTTR by year and theater of operation, with associated age, gender, military rank, branch of military service, Injury Severity Score (ISS), medical care level at the time of diagnosis (Level I, II, III, IV, and V), battle injuries (BI) or non-BI, injury site(s), Glasgow Coma Scale (GCS), and mechanism(s) of injury. Other variables included transfused blood products along with the receipt of massive transfusion (defined as 10 or more units of packed red blood cells (PRBCs) or whole blood during the first 24 hours after injury), duration of hospitalization, duration of ICU stay, and duration of mechanical ventilation. Injury patterns were grouped by anatomic distribution, which were determined by the presence of 1 or more non-zero ordinal scores specific to that body region within the Military Abbreviated Injury Scale (MAIS). MAIS body regions were grouped accordingly: head/neck, face, thorax, including injury to spine; abdomen, including injury to pelvic contents; extremity injury, whether upper or lower; and external injury, including burns and other trauma.

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### TABLE 1. Total Number of Individual Recorded Diagnosis/Procedure Codes by Trauma and Infections Reviewed From the JTTR for OIF and OEF

<table>
<thead>
<tr>
<th>Combat Zone</th>
<th>Number of Patients</th>
<th>Total</th>
<th>2003</th>
<th>2004</th>
<th>2005</th>
<th>2006</th>
<th>2007</th>
<th>2008</th>
<th>2009</th>
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<tbody>
<tr>
<td>OIF/OEF</td>
<td>16,742</td>
<td>6,277 (129)</td>
<td>3,503 (82)</td>
<td>3,975 (97)</td>
<td>3,752 (86)</td>
<td>3,465 (36)</td>
<td>3,297 (24)</td>
<td>2,518 (6)</td>
<td>1,146 (0)</td>
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<tr>
<td>OIF</td>
<td>15,021</td>
<td>6,114 (127)</td>
<td>3,453 (80)</td>
<td>3,926 (95)</td>
<td>3,678 (83)</td>
<td>3,372 (35)</td>
<td>3,132 (24)</td>
<td>2,218 (6)</td>
<td>855 (0)</td>
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<td>Battle injuries</td>
<td>9,883</td>
<td>5,474 (116)</td>
<td>2,643 (67)</td>
<td>3,567 (89)</td>
<td>3,385 (78)</td>
<td>3,102 (29)</td>
<td>2,873 (19)</td>
<td>1,885 (4)</td>
<td>623 (0)</td>
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<tr>
<td>Non-battle injuries</td>
<td>4,971</td>
<td>3,928 (76)</td>
<td>2,332 (51)</td>
<td>1,989 (44)</td>
<td>1,851 (29)</td>
<td>1,586 (14)</td>
<td>1,401 (6)</td>
<td>1,339 (3)</td>
<td>487 (0)</td>
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<tr>
<td>OEF</td>
<td>1,721</td>
<td>2,981 (41)</td>
<td>752 (16)</td>
<td>1,010 (16)</td>
<td>1,188 (17)</td>
<td>1,315 (6)</td>
<td>1,373 (0)</td>
<td>1,600 (1)</td>
<td>704 (0)</td>
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<tr>
<td>Battle injuries</td>
<td>1,090</td>
<td>2,557 (35)</td>
<td>455 (14)</td>
<td>759 (15)</td>
<td>910 (13)</td>
<td>991 (4)</td>
<td>1,137 (0)</td>
<td>1,496 (1)</td>
<td>629 (0)</td>
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<tr>
<td>Non-battle injuries</td>
<td>599</td>
<td>1,604 (10)</td>
<td>410 (1)</td>
<td>437 (1)</td>
<td>529 (7)</td>
<td>663 (3)</td>
<td>614 (0)</td>
<td>490 (0)</td>
<td>202 (0)</td>
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Values given in parentheses are number of infections.
**TABLE 2.** Patient Demographics in the JTTR for Casualties of OIF and OEF

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<tr>
<th></th>
<th>Total</th>
<th>2003</th>
<th>2004</th>
<th>2005</th>
<th>2006</th>
<th>2007</th>
<th>2008</th>
<th>2009</th>
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<tr>
<td>Number of patients</td>
<td>16,742</td>
<td>2,703</td>
<td>3,500</td>
<td>2,561</td>
<td>2,711</td>
<td>3,047</td>
<td>1,883</td>
<td>337</td>
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<td>Gender, n (%)</td>
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<tr>
<td>Female</td>
<td>561 (3.4)</td>
<td>144 (5.3)</td>
<td>115 (3.3)</td>
<td>81 (3.2)</td>
<td>66 (2.4)</td>
<td>87 (2.9)</td>
<td>55 (2.9)</td>
<td>13 (3.9)</td>
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<tr>
<td>Male</td>
<td>16,178 (90.6)</td>
<td>2,559 (94.7)</td>
<td>3,385 (96.7)</td>
<td>2,477 (96.7)</td>
<td>2,645 (97.6)</td>
<td>2,960 (97.1)</td>
<td>1,828 (97.1)</td>
<td>324 (96.1)</td>
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<td>0 (0.0)</td>
<td>0 (0.0)</td>
<td>3 (0.1)</td>
<td>3 (0.1)</td>
<td>0 (0.0)</td>
<td>0 (0.0)</td>
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<td>Branch of service, n (%)</td>
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<tr>
<td>Army</td>
<td>12,995 (77.6)</td>
<td>2,371 (87.7)</td>
<td>2,396 (68.5)</td>
<td>1,877 (73.3)</td>
<td>1,987 (73.3)</td>
<td>2,543 (83.5)</td>
<td>1,543 (81.9)</td>
<td>278 (82.5)</td>
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<tr>
<td>Marine</td>
<td>2,991 (17.9)</td>
<td>262 (9.7)</td>
<td>940 (26.9)</td>
<td>569 (22.2)</td>
<td>569 (21.0)</td>
<td>380 (12.5)</td>
<td>232 (12.3)</td>
<td>39 (11.6)</td>
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<td>Air force</td>
<td>374 (2.2)</td>
<td>37 (1.4)</td>
<td>75 (2.1)</td>
<td>59 (2.3)</td>
<td>66 (2.4)</td>
<td>72 (2.4)</td>
<td>52 (2.8)</td>
<td>13 (3.9)</td>
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<tr>
<td>Navy</td>
<td>382 (2.3)</td>
<td>33 (1.2)</td>
<td>89 (2.5)</td>
<td>89 (3.3)</td>
<td>52 (1.7)</td>
<td>56 (3.0)</td>
<td>7 (2.1)</td>
<td>0 (0.0)</td>
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<td>Military grade/rank, n (%)</td>
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<td>Enlisted</td>
<td>15,508 (92.6)</td>
<td>2,493 (92.2)</td>
<td>3,266 (93.3)</td>
<td>2,371 (92.6)</td>
<td>2,535 (93.5)</td>
<td>2,822 (92.6)</td>
<td>1,710 (90.8)</td>
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<td>159 (5.9)</td>
<td>195 (5.6)</td>
<td>154 (6.0)</td>
<td>159 (5.9)</td>
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<td>22 (0.9)</td>
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<td>Alive</td>
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<td>3,459 (98.8)</td>
<td>2,545 (99.4)</td>
<td>2,692 (99.3)</td>
<td>3,038 (99.7)</td>
<td>1,881 (99.9)</td>
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<td>Dead</td>
<td>111 (0.7)</td>
<td>22 (0.8)</td>
<td>41 (1.2)</td>
<td>16 (0.6)</td>
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<td>9 (0.3)</td>
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<td>OIF</td>
<td>15,021 (89.7)</td>
<td>2,575 (95.3)</td>
<td>3,344 (95.5)</td>
<td>2,377 (92.6)</td>
<td>2,402 (88.6)</td>
<td>2,645 (88.6)</td>
<td>1,420 (75.4)</td>
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<td>Battle injury</td>
<td>9,883 (65.8)</td>
<td>1,085 (42.1)</td>
<td>2,381 (71.2)</td>
<td>1,734 (72.9)</td>
<td>1,822 (75.9)</td>
<td>2,029 (76.7)</td>
<td>719 (50.6)</td>
<td>113 (43.8)</td>
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<td>Total OEF, n (%)</td>
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<td>1,721 (10.3)</td>
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<td>156 (4.5)</td>
<td>184 (7.2)</td>
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<td>402 (13.2)</td>
<td>463 (24.6)</td>
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<td>1,090 (63.3)</td>
<td>46 (35.9)</td>
<td>78 (50.0)</td>
<td>91 (49.5)</td>
<td>174 (56.3)</td>
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<td>3.4 (1–6)</td>
<td>3.1 (1–6)</td>
<td>2.3 (1–6)</td>
<td>2.2 (1–6)</td>
<td>2.0 (1–6)</td>
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<td>Face, mean (range)</td>
<td>1.5 (1–6)</td>
<td>1.3 (1–5)</td>
<td>1.5 (1–5)</td>
<td>1.5 (1–5)</td>
<td>1.5 (1–5)</td>
<td>1.5 (1–5)</td>
<td>1.5 (1–5)</td>
<td>1.6 (1–6)</td>
</tr>
<tr>
<td>Thorax, mean (range)</td>
<td>2.8 (1–6)</td>
<td>2.6 (1–5)</td>
<td>2.8 (1–6)</td>
<td>2.8 (1–6)</td>
<td>2.8 (1–6)</td>
<td>2.8 (1–6)</td>
<td>2.8 (1–6)</td>
<td>2.6 (1–6)</td>
</tr>
<tr>
<td>Abdomen, mean (range)</td>
<td>2.4 (1–6)</td>
<td>2.0 (1–5)</td>
<td>2.4 (1–5)</td>
<td>2.5 (1–5)</td>
<td>2.5 (1–5)</td>
<td>2.5 (1–5)</td>
<td>2.3 (1–5)</td>
<td>2.4 (1–5)</td>
</tr>
<tr>
<td>Extremities, mean (range)</td>
<td>2.4 (1–6)</td>
<td>2.1 (1–5)</td>
<td>2.4 (1–6)</td>
<td>2.5 (1–6)</td>
<td>2.6 (1–5)</td>
<td>2.3 (1–5)</td>
<td>2.2 (1–6)</td>
<td>2.1 (1–6)</td>
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### TABLE 2. Patient Demographics in the JTTR for Casualties of OIF and OEF (continued)

<table>
<thead>
<tr>
<th></th>
<th>Total 2003 (range)</th>
<th>2004 (range)</th>
<th>2005 (range)</th>
<th>2006 (range)</th>
<th>2007 (range)</th>
<th>2008 (range)</th>
<th>2009 (range)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>External, mean</strong></td>
<td>1.2 (1–6)</td>
<td>1.1 (1–5)</td>
<td>1.2 (1–6)</td>
<td>1.3 (1–6)</td>
<td>1.3 (1–6)</td>
<td>1.3 (1–6)</td>
<td>1.2 (1–5)</td>
</tr>
<tr>
<td><strong>Hospital days, median</strong></td>
<td>4 (0–2196)</td>
<td>4 (0–2196)</td>
<td>5 (0–1107)</td>
<td>5 (1–1524)</td>
<td>4 (1–1099)</td>
<td>3 (0–759)</td>
<td>2 (1–366)</td>
</tr>
<tr>
<td>Venticulator days, median</td>
<td>0 (0–405)</td>
<td>0 (0–34)</td>
<td>0 (0–75)</td>
<td>0 (0–405)</td>
<td>0 (0–87)</td>
<td>0 (0–97)</td>
<td>0 (0–36)</td>
</tr>
<tr>
<td>Days in the ICU, median</td>
<td>1 (0–337)</td>
<td>1 (0–220)</td>
<td>1 (0–37)</td>
<td>1 (0–103)</td>
<td>1 (0–87)</td>
<td>0 (0–23)</td>
<td>0 (0–204)</td>
</tr>
<tr>
<td>Massive transfusion, number of patients</td>
<td>768</td>
<td>32</td>
<td>132</td>
<td>149</td>
<td>183</td>
<td>180</td>
<td>83</td>
</tr>
<tr>
<td>Whole blood, median (range)</td>
<td>0 (0–56)</td>
<td>0 (0–20)</td>
<td>0 (0–27)</td>
<td>0 (0–38)</td>
<td>0 (0–44)</td>
<td>0 (0–56)</td>
<td>0 (0–16)</td>
</tr>
<tr>
<td>Red blood cell, median (range)</td>
<td>6 (0–74)</td>
<td>5 (0–22)</td>
<td>5 (0–41)</td>
<td>5 (0–69)</td>
<td>6 (0–70)</td>
<td>7 (0–66)</td>
<td>7 (1–74)</td>
</tr>
<tr>
<td>Platelet, median (range)</td>
<td>0 (0–34)</td>
<td>0 (0–0)</td>
<td>0 (0–4)</td>
<td>0 (0–34)</td>
<td>0 (0–19)</td>
<td>0 (0–16)</td>
<td>0 (0–20)</td>
</tr>
<tr>
<td>Cryoprecipitate, median (range)</td>
<td>0 (0–13)</td>
<td>0 (0–0)</td>
<td>0 (0–7)</td>
<td>0 (0–11)</td>
<td>0 (0–7)</td>
<td>0 (0–13)</td>
<td>0 (0–6)</td>
</tr>
<tr>
<td>Fresh frozen plasma, median (range)</td>
<td>4 (0–82)</td>
<td>0 (0–18)</td>
<td>1 (0–33)</td>
<td>3 (0–47)</td>
<td>4 (0–61)</td>
<td>5 (0–82)</td>
<td>5 (0–62)</td>
</tr>
<tr>
<td>Red blood cell + whole blood, median (range)</td>
<td>6 (0–107)</td>
<td>5 (0–35)</td>
<td>6 (0–66)</td>
<td>5 (1–107)</td>
<td>6 (1–97)</td>
<td>8 (1–105)</td>
<td>7 (1–74)</td>
</tr>
<tr>
<td>Infectious events*, 1 or more</td>
<td>921 (5.5)</td>
<td>220 (8.1)</td>
<td>319 (9.1)</td>
<td>278 (10.9)</td>
<td>62 (2.3)</td>
<td>30 (10)</td>
<td>12 (0.6)</td>
</tr>
</tbody>
</table>

Massive transfusion, defined as 10 or more units of blood product support.

* Possible underreporting due to limitations described in the discussion section.
**Figure 1.** (A) Number of patients by mechanism of injury. (B) Distribution of trauma over time.

**TABLE 3.** Infection ICD-9 Coding Based on Anatomical/Clinical Syndrome or Pathogen Bundled*

<table>
<thead>
<tr>
<th>Syndrome</th>
<th>Total</th>
<th>2003</th>
<th>2004</th>
<th>2005</th>
<th>2006</th>
<th>2007</th>
<th>2008</th>
<th>2009</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Anatomical and clinical syndrome</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Abdomen</td>
<td>61</td>
<td>11</td>
<td>28</td>
<td>13</td>
<td>6</td>
<td>2</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Bacteremia</td>
<td>111</td>
<td>27</td>
<td>44</td>
<td>36</td>
<td>2</td>
<td>2</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Bone/joint</td>
<td>66</td>
<td>17</td>
<td>30</td>
<td>17</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Central nervous system</td>
<td>13</td>
<td>5</td>
<td>4</td>
<td>1</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Lung</td>
<td>156</td>
<td>36</td>
<td>52</td>
<td>54</td>
<td>8</td>
<td>4</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Other</td>
<td>327</td>
<td>107</td>
<td>134</td>
<td>72</td>
<td>10</td>
<td>4</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Skin/wound</td>
<td>286</td>
<td>67</td>
<td>97</td>
<td>78</td>
<td>20</td>
<td>16</td>
<td>8</td>
<td>0</td>
</tr>
<tr>
<td>Urine</td>
<td>50</td>
<td>10</td>
<td>27</td>
<td>11</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>Pathogen</strong></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gram-negative</td>
<td>449</td>
<td>108</td>
<td>178</td>
<td>146</td>
<td>15</td>
<td>2</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Gram-positive</td>
<td>227</td>
<td>62</td>
<td>88</td>
<td>61</td>
<td>10</td>
<td>6</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Other bacteria</td>
<td>195</td>
<td>60</td>
<td>72</td>
<td>58</td>
<td>5</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Fungus</td>
<td>73</td>
<td>15</td>
<td>24</td>
<td>24</td>
<td>8</td>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>

Patients may have received more than one infectious code.

* Possible underreporting due to limitations described in the Discussion section.
### TABLE 4. Infectious ICD-9 Coding by Pathogen

<table>
<thead>
<tr>
<th>Syndrome</th>
<th>Code</th>
<th>Code Description</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Fungus</strong></td>
<td>112</td>
<td>Candidiasis of mouth</td>
<td>7</td>
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<tr>
<td>112.1</td>
<td>Vulva/vaginal candidiasis</td>
<td>3</td>
<td></td>
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<tr>
<td>112.3</td>
<td>Candidiasis of skin/nails</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>112.5</td>
<td>Disseminated candidiasis</td>
<td>4</td>
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</tr>
<tr>
<td>112.89</td>
<td>Candidiasis site nec</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>112.9</td>
<td>Candidiasis site unspec</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td>117.3</td>
<td>Aspergillosis</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>117.9</td>
<td>Mycoses</td>
<td>16</td>
<td></td>
</tr>
<tr>
<td><strong>Gram-negative</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>041.3</td>
<td>Klebsiella infect nos</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>041.7</td>
<td><em>Pseudomonas</em> infect unspec</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>041.85</td>
<td>Infection Gram Neg OT</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>3.8</td>
<td>Other <em>Salmonella</em> infections</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>38.42</td>
<td><em>Escherichia coli</em> septicemia</td>
<td>1</td>
<td></td>
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<tr>
<td>38.43</td>
<td><em>Pseudomonas</em> septicemia</td>
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<td></td>
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<td>38.49</td>
<td>Gram-neg septicemia nec</td>
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<td></td>
</tr>
<tr>
<td>41.3</td>
<td>Klebsiella infect nos</td>
<td>90</td>
<td></td>
</tr>
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<td>41.4</td>
<td><em>E. coli</em> infection nos</td>
<td>43</td>
<td></td>
</tr>
<tr>
<td>41.6</td>
<td>Proteus infection unspec</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>41.7</td>
<td><em>Pseudomonas</em> infection unspec</td>
<td>97</td>
<td></td>
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<tr>
<td>41.85</td>
<td>Infection Gram negative OT</td>
<td>168</td>
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<tr>
<td><strong>Gram-positive</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>041.02</td>
<td>Infection <em>Streptococcus</em> group B</td>
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<tr>
<td>041.11</td>
<td><em>Staphylococcus</em> aureus</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>041.19</td>
<td>Infection <em>Staphylococcus</em> OT</td>
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</tr>
<tr>
<td>38</td>
<td><em>Streptococcal</em> septicemia</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>38.11</td>
<td><em>S. aureus</em> septicemia</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>38.19</td>
<td><em>Staphylococcus</em> septicemia OT</td>
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<td>GAS</td>
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<tr>
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<td><em>Streptococcus</em> unspec</td>
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<td>41.01</td>
<td>Infection <em>Streptococcus</em> group A</td>
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<td>41.02</td>
<td>Infection <em>Streptococcus</em> group B</td>
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<tr>
<td>41.03</td>
<td>Infection <em>Streptococcus</em> group C</td>
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<td>41.04</td>
<td>Enterococcus group D</td>
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<tr>
<td>41.09</td>
<td>Other <em>Streptococcus</em></td>
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<td><em>Staphylococcus</em> unspec</td>
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<td>41.11</td>
<td><em>S. aureus</em></td>
<td>66</td>
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<tr>
<td>41.19</td>
<td>Infection <em>Staphylococcus</em> OT</td>
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<tr>
<td>481</td>
<td>Pneumococcal pneumonia</td>
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<td>482.3</td>
<td><em>Streptococcus</em> pneumonia unspec</td>
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<td>482.31</td>
<td>Group A <em>Streptococcus</em> pneumonia</td>
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<td>482.4</td>
<td><em>Staphylococcus</em> pneumonia nos</td>
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<td>482.41</td>
<td><em>Pneumonia S. aureus</em></td>
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<tr>
<td><strong>Other bacteria</strong></td>
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<td>041.89</td>
<td>Other specified bacteria</td>
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<td>32.89</td>
<td>Other specified diphtheria</td>
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<td>41.82</td>
<td><em>Bacteroides fragilis</em> infection</td>
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<tr>
<td>41.83</td>
<td><em>Clostridium perfringens</em> infection</td>
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<td>41.84</td>
<td>Other anaerobes</td>
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</tr>
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<td>41.89</td>
<td>Other specified bacteria</td>
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<td><em>Bacterial</em> infection nos</td>
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<td>Other nonspecific positive culture</td>
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<td>8.45</td>
<td><em>Clostridium difficile</em> enteritis</td>
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<tr>
<td>V09.0</td>
<td>Penicillin-resistant microorganism</td>
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</tbody>
</table>

### TABLE 5. Infection ICD-9 Coding by Anatomical and Clinical Syndrome Based

<table>
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<tr>
<th>Syndrome</th>
<th>Code</th>
<th>Code Description</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Abdomen</strong></td>
<td>567.2</td>
<td>Suppurat peritonitis OT</td>
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<td>567.8</td>
<td>Peritonitis OT</td>
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<tr>
<td>567.9</td>
<td>Peritonitis unspec</td>
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<tr>
<td>568</td>
<td>Peritoneal Adhesions Postop/infection</td>
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<td>569.6</td>
<td>Colostomy/enterostomy comp unspec</td>
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<tr>
<td>569.61</td>
<td>Colostomy/enterostomy infect</td>
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</tr>
<tr>
<td>577</td>
<td>Acute pancreatitis</td>
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</tr>
<tr>
<td>8</td>
<td>Enteritis <em>Escherichia coli</em> unspec</td>
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<td></td>
</tr>
<tr>
<td><strong>Bacteremia</strong></td>
<td>38</td>
<td><em>Streptococcal</em> septicemia</td>
<td>1</td>
</tr>
<tr>
<td>38.11</td>
<td><em>Staphylococcus aureus</em> septicemia</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>38.19</td>
<td><em>Staphylococcus</em> septicemia OT</td>
<td>3</td>
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<tr>
<td>38.42</td>
<td><em>E. coli</em> septicemia</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>38.43</td>
<td><em>Pseudomonas</em> septicemia</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>38.49</td>
<td>Gram-negative septicemia nec</td>
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</tr>
<tr>
<td>38.8</td>
<td>Septicemia OT</td>
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<td></td>
</tr>
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<td>38.9</td>
<td>Septicemia nos</td>
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<td>790.7</td>
<td>Bacteremia</td>
<td>85</td>
<td></td>
</tr>
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<td><strong>Bone/joint</strong></td>
<td>730.02</td>
<td>Acute osteomyelitis arm</td>
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<td>730.05</td>
<td>Acute osteomyelitis pelvis</td>
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<td></td>
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<tr>
<td>730.06</td>
<td>Acute osteomyelitis leg</td>
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<td></td>
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<tr>
<td>730.07</td>
<td>Acute osteomyelitis ankle</td>
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<td>Chronic osteomyelitis leg</td>
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<tr>
<td>730.22</td>
<td>Osteomyelitis unspec arm</td>
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<td>Osteomyelitis unspec forearm</td>
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<td></td>
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<td>Osteomyelitis unspec pelvis</td>
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<tr>
<td>730.26</td>
<td>Osteomyelitis nos-L/leg</td>
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<td></td>
</tr>
<tr>
<td>730.27</td>
<td>Osteomyelitis unspec ankle</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>730.28</td>
<td>Osteomyelitis unspec OT site</td>
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<td></td>
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<td>996.66</td>
<td>Infection joint prosthes</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>996.67</td>
<td>Infection orthopedic device OT</td>
<td>16</td>
<td></td>
</tr>
<tr>
<td><strong>Central nervous system</strong></td>
<td>320.89</td>
<td>Meningitis other spec bact</td>
<td>1</td>
</tr>
<tr>
<td>320.9</td>
<td>Bacterial meningitis unspec</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>322.9</td>
<td>Meningitis unspec</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td><strong>Lung</strong></td>
<td>465.9</td>
<td>Acute URI nos</td>
<td>6</td>
</tr>
<tr>
<td>481</td>
<td>Pneumococcal pneumonia</td>
<td>11</td>
<td></td>
</tr>
<tr>
<td>482.1</td>
<td>Pseudomonal pneumonia</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>482.31</td>
<td>Group A <em>Strept pneumonia</em></td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>482.4</td>
<td><em>Staphylococcal</em> pneumonia nos</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>482.41</td>
<td>Pneumonia <em>S. aureus</em></td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>482.82</td>
<td><em>E. coli</em> pneumonia</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>482.83</td>
<td>Gram negative pneumonia OT</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>482.89</td>
<td><em>Bacterial pneumonia</em> OT</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td>486</td>
<td>Pneumonia, organism nos</td>
<td>75</td>
<td></td>
</tr>
<tr>
<td>510</td>
<td>Empyema with fistula</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>510.9</td>
<td>Empyema w/o fistula</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>513</td>
<td>Abscess of lung</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td><strong>Other</strong></td>
<td>041.89</td>
<td>Infection bacteria OT</td>
<td>7</td>
</tr>
<tr>
<td>112.1</td>
<td>Vulva/vaginal candidiasis</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>320.9</td>
<td>Bacterial meningitis nos</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>381.4</td>
<td>Nonsuppurative otitis media unspec</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>41.89</td>
<td>Infection bacteria OT</td>
<td>133</td>
<td></td>
</tr>
</tbody>
</table>
Poisson regression directly incorporating each individual’s known posttrauma time at risk. Potential within-patient dependence of infectious complications and any resulting extra-Poisson variation were accommodated by estimating a scale parameter (rather than fixing it at 1) to adjust standard errors for over dispersion and mitigate inadvertently increasing the chance of false positive conclusions beyond the targeted 5% level.

RESULTS

We reviewed data from 16,742 patients, 15,021 from Operation Iraqi Freedom (OIF; 9,883 BI, 4,971 non-BI [NBI]) and 1,721 from Operation Enduring Freedom (OEF; 1,090 BI, 599 NBI; Table 1). This represents approximately 70% of the evacuations during the study period. There were 2,703 patient records in 2003, 3,500 in 2004, 2,561 in 2005, 2,711 in 2006, 3,047 in 2007, 1,883 in 2008, and 337 in 2009. The highest number of trauma and infectious ICD-9 codes were from 2003 to 2005 (Table 1), which is consistent with the unavoidable lag in extracting medical records for recent years.

Most patients were male (96.6%) Army personnel (77.6%), 17.9% Marines, and the balance were Air Force and Navy (Table 2). The majority of patients were enlisted (92.6%). The average military ISS ranged from a low of 6.2 in 2003 to a high of 12.5 in 2006. The GCS ranged from 3 to 15 with the highest mean per year of 14.2 in 2003 and a low of 12.7 in 2005. The majority of BI were due to explosive devices while for NBI

Table 5. Infection ICD-9 Coding by Anatomical and Clinical Syndrome Based (continued)

<table>
<thead>
<tr>
<th>Syndrome</th>
<th>Code</th>
<th>Code Description</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>420.9</td>
<td>Acute pericarditis unspec</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>451.82</td>
<td>Superficial phlebitis arm</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>451.83</td>
<td>Deep phlebitis arm</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>451.89</td>
<td>Thrombophlebitis OT</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>451.9</td>
<td>Thrombophlebitis nos</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>519.2</td>
<td>Mediastinitis</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>604</td>
<td>Orchitis with abscess</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>910.5</td>
<td>Insect bite head infection</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>98</td>
<td>Acute GC infect lower GU</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>995.9</td>
<td>SIRS, unspec</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>995.91</td>
<td>SIRS infection w/o organ dysfun</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>995.92</td>
<td>SIRS infection w/organ dysfun</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>996.6</td>
<td>Infection due to device unspec</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>996.62</td>
<td>Infection due to vascular device</td>
<td>28</td>
<td></td>
</tr>
<tr>
<td>996.69</td>
<td>Infection due to device OT</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>998.39</td>
<td>Other postoperative infection</td>
<td>88</td>
<td></td>
</tr>
<tr>
<td>Skin/wound</td>
<td>519.01</td>
<td>Tracheostomy infection</td>
<td>1</td>
</tr>
<tr>
<td>528.3</td>
<td>Cellulitis/abscess mouth</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>566</td>
<td>Anal/rectal abscess</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>682</td>
<td>Cellulitis/abscess face</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>682.1</td>
<td>Cellulitis/abscess neck</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>682.2</td>
<td>Cellulitis trunk</td>
<td>13</td>
<td></td>
</tr>
<tr>
<td>682.3</td>
<td>Cellulitis arm</td>
<td>29</td>
<td></td>
</tr>
<tr>
<td>682.4</td>
<td>Cellulitis hand</td>
<td>14</td>
<td></td>
</tr>
<tr>
<td>682.5</td>
<td>Cellulitis/abscess buttoc</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>682.6</td>
<td>Cellulitis leg</td>
<td>56</td>
<td></td>
</tr>
<tr>
<td>682.7</td>
<td>Cellulitis foot</td>
<td>24</td>
<td></td>
</tr>
<tr>
<td>682.9</td>
<td>Unspec cellulitis/abscess</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>869.6</td>
<td>Local skin infection unspec</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>728.86</td>
<td>Necrotizing fasciitis</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>785.4</td>
<td>Gangrene</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>912.1</td>
<td>Abrasion shldr/arm infcc</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>916.1</td>
<td>Abrasion hip/leg infection</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>916.3</td>
<td>Blister hip/leg infection</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>917.3</td>
<td>Blister foot and toe-infection</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>958.3</td>
<td>Posttrauma wound infection nec</td>
<td>71</td>
<td></td>
</tr>
<tr>
<td>997.62</td>
<td>Infection amputation stump</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>Urine</td>
<td>599</td>
<td>Urinary tract infection nos</td>
<td>40</td>
</tr>
<tr>
<td>788.3</td>
<td>Urinary incontinence nos</td>
<td>10</td>
<td></td>
</tr>
</tbody>
</table>

Nec, not elsewhere classified; nos, not otherwise specified; OT, other; unspec, unspecified; URI, upper respiratory infection; SIRS, systemic inflammatory response syndrome.

Figure 2. Discharge status of infectious complications among those patients coded as alive or dead with percentage of died with that complication.
motor vehicle crash was most commonly documented (Fig. 1, A and B). The median number of days of hospitalization was 4 with a range of 0 days to 2,196 days. The median number of days requiring mechanical ventilation was 0 with a range of 0 days to 405 days. The median number of days requiring mechanical ventilation was 0 with a range of 0 days to 405 days. The median days in the ICU was 1 with a range of 0 days to 337 days (Table 2). Massive transfusions occurred in 768 patients with the highest yearly use in 2006 (Table 2). Individual blood product support, such as red blood cells, fresh frozen plasma and the combination of red blood cells and whole blood, had a higher median use per patient during the later years of the study. The greatest use of transfusions according to combat zone during OIF during 2005 (mean 19.3 units of PRBCs and 2.9 units of whole blood) while in OEF it occurred during early 2008 (mean 15.8 units of PRBCs and 2.2 units of whole blood).

A total of 921 (5.5%) patients had 1 or more infections codes with clear decreases over the study period (Table 2), although this may simply be an artifact of unavoidable lag in the extraction of data from electronic medical records into the JTTR or data extraction concerns. The commonly coded bacteria were gram-negatives (47.6%) and gram-positives (24.0%; Tables 3 and 4). The most common anatomic or clinical syndrome codes were skin/wound infection (26.7%) followed by lung (14.6%; Table 6). There were 111 deaths of which 16 (14%) were infected (Fig. 2). Injury patterns as quantified by MAIS reveal that patients with injuries to the pelvis and external soft tissue had the highest number of infections (Table 7).

Numerous risk factors associated with infection on univariate analysis were present including BI, ISS, body region injured, OEF versus OIF, year of injury, GCS, transfusions, along with ICU, ventilator, and hospital days (Tables 8 and 9 for odds ratios and incidence density rate ratios, respectively). On multivariate analysis, year of injury, mechanism of injury, increasing ISS, and injury pattern were associated with infections. Association with infection on multivariate analysis held true for incidence density rate of infections per 100 person-days after injury to time of infection (Table 10).

**DISCUSSION**

Continued emphasis on system wide data pertaining to combat-related injury infections is required to improve the overall outcomes of our casualties. This study expands on the numerous single facility, injury site-specific studies and the only previous evaluation of the JTTR for infection specific outcomes for all entries available. Overall, 5.5% of 16,742 casualties assessed in this study had the presence of an infection. These infections involved primarily skin and wound sites or the lung, with a high rate of bacteremia. As in the wars in Iraq and Afghanistan, along with previous conflicts, extremity injuries have been the most commonly encountered injury pattern. It has been noted that

### TABLE 7. Infections Based on Injury Pattern

<table>
<thead>
<tr>
<th>Infectious Complications Noted/Injury Pattern (by Body Region)</th>
<th>OEF</th>
<th>None</th>
<th>1 or More, n (%)</th>
<th>OIF</th>
<th>None</th>
<th>1 or More, n (%)</th>
<th>Overall</th>
<th>None</th>
<th>1 or More, n (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Head/neck</td>
<td>542</td>
<td>535</td>
<td>7 (1.3)</td>
<td>3,888</td>
<td>3,695</td>
<td>193 (5.2)</td>
<td>4,430</td>
<td>4,230</td>
<td>200 (4.7)</td>
</tr>
<tr>
<td>Face</td>
<td>319</td>
<td>310</td>
<td>9 (2.9)</td>
<td>2,939</td>
<td>2,738</td>
<td>201 (7.3)</td>
<td>3,568</td>
<td>3,283</td>
<td>210 (6.2)</td>
</tr>
<tr>
<td>Thorax</td>
<td>196</td>
<td>188</td>
<td>8 (4.3)</td>
<td>1,572</td>
<td>1,400</td>
<td>172 (12.3)</td>
<td>1,768</td>
<td>1,588</td>
<td>180 (11.3)</td>
</tr>
<tr>
<td>Abdomen</td>
<td>178</td>
<td>171</td>
<td>7 (4.1)</td>
<td>1,664</td>
<td>1,480</td>
<td>184 (12.4)</td>
<td>1,832</td>
<td>1,658</td>
<td>180 (11.3)</td>
</tr>
<tr>
<td>Extremities</td>
<td>840</td>
<td>812</td>
<td>28 (3.4)</td>
<td>7,454</td>
<td>6,931</td>
<td>523 (7.5)</td>
<td>9,879</td>
<td>9,192</td>
<td>687 (7.5)</td>
</tr>
<tr>
<td>External</td>
<td>1,066</td>
<td>1,031</td>
<td>35 (3.4)</td>
<td>6,954</td>
<td>6,431</td>
<td>452 (6.7)</td>
<td>8,020</td>
<td>7,485</td>
<td>425 (5.3)</td>
</tr>
</tbody>
</table>

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during OIF/OEF there has been a lower proportion of thoracic wounds than in past conflicts. Of those who suffered a torso injury in this study, there is a relatively higher rate of infectious complications. The approximate 11% infectious complication rate among abdominal and thoracic injured patients was higher than the rates described in the Vietnam war of 3.8% and 6.9%, but similar to other reports from Iraq.

On multivariate analysis, risk factors associated with infections in this study primarily were year of injury, mech-

**TABLE 8.** Univariate Analysis of Risk Factors Associated With Development of an Infection (Logistic Regression Using 1 or More Terms Included to Estimate the Overall Effect of Each Predictor)

<table>
<thead>
<tr>
<th>Risk Factor</th>
<th>N</th>
<th>Comparison</th>
<th>Odds Ratio</th>
<th>95% Confidence Interval</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>ISS/MAIS</td>
<td>13,310</td>
<td>Head/neck vs. not</td>
<td>0.20</td>
<td>0.12–0.33</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Body region</td>
<td>95,41</td>
<td>Extremity vs. not</td>
<td>0.53</td>
<td>0.37–0.76</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td></td>
<td>15,011</td>
<td>Face vs. not</td>
<td>1.17</td>
<td>0.95–1.43</td>
<td>0.13</td>
</tr>
<tr>
<td></td>
<td>14,732</td>
<td>Thorax vs. not</td>
<td>0.94</td>
<td>0.83–2.32</td>
<td>0.90</td>
</tr>
<tr>
<td></td>
<td>14,871</td>
<td>Abdomen vs. not</td>
<td>1.15</td>
<td>0.71–1.87</td>
<td>0.56</td>
</tr>
<tr>
<td></td>
<td>14,955</td>
<td>External vs. not</td>
<td>2.08</td>
<td>1.74–2.49</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Age</td>
<td>16,392</td>
<td>Age (1 yr increase)</td>
<td>1.01</td>
<td>1.00–1.02</td>
<td>0.35</td>
</tr>
<tr>
<td></td>
<td>18–21 vs. 30–60</td>
<td>0.83</td>
<td>0.69–1.00</td>
<td>0.06</td>
<td></td>
</tr>
<tr>
<td></td>
<td>22–24 vs. 30–60</td>
<td>0.98</td>
<td>0.81–1.17</td>
<td>0.37</td>
<td></td>
</tr>
<tr>
<td></td>
<td>25–29 vs. 30–60</td>
<td>0.91</td>
<td>0.75–1.11</td>
<td>0.79</td>
<td></td>
</tr>
<tr>
<td>Gender</td>
<td>16,402</td>
<td>Female vs. male</td>
<td>1.08</td>
<td>0.76–1.55</td>
<td>0.67</td>
</tr>
<tr>
<td>Branch of service</td>
<td>16,405</td>
<td>Marine vs. Army</td>
<td>0.56</td>
<td>0.45–0.68</td>
<td>0.54</td>
</tr>
<tr>
<td></td>
<td>15,011</td>
<td>Air Force vs. Army</td>
<td>0.47</td>
<td>0.26–0.87</td>
<td>0.32</td>
</tr>
<tr>
<td></td>
<td>14,732</td>
<td>Navy vs. Army</td>
<td>0.50</td>
<td>0.28–0.89</td>
<td>0.42</td>
</tr>
<tr>
<td>Injury class</td>
<td>16,206</td>
<td>Battle vs. non-battle</td>
<td>2.09</td>
<td>1.77–2.47</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Military grade/rank</td>
<td>16,296</td>
<td>Officer vs. enlisted</td>
<td>1.04</td>
<td>0.80–1.35</td>
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</tr>
<tr>
<td>Disposition</td>
<td>16,405</td>
<td>Dead vs. alive</td>
<td>2.93</td>
<td>1.71–4.99</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Operation</td>
<td>16,405</td>
<td>OEF vs. OIF</td>
<td>0.44</td>
<td>0.32–0.59</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>MILISS</td>
<td>16,402</td>
<td>MILISS</td>
<td>1.03</td>
<td>1.03–1.03</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td></td>
<td>15–29 vs. low-14</td>
<td>3.71</td>
<td>3.15–4.36</td>
<td>&lt;0.001</td>
<td></td>
</tr>
<tr>
<td></td>
<td>30-high vs. low-14</td>
<td>4.53</td>
<td>3.79–5.40</td>
<td>&lt;0.001</td>
<td></td>
</tr>
<tr>
<td>Hospital data</td>
<td>16,251</td>
<td>Hospitalization (d)</td>
<td>1.01</td>
<td>1.01–1.01</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td></td>
<td>15,575</td>
<td>Ventilation (d)</td>
<td>1.19</td>
<td>1.17–1.22</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td></td>
<td>15,725</td>
<td>ICU (d)</td>
<td>1.14</td>
<td>1.12–1.15</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>GCS summaries</td>
<td>13,435</td>
<td>Minimum GCS</td>
<td>0.88</td>
<td>0.86–0.89</td>
<td>&lt;0.001</td>
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<tr>
<td></td>
<td>16,404</td>
<td>GCS (single imputation of 15 for missing values)</td>
<td>0.87</td>
<td>0.86–0.89</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Overall* injury pattern</td>
<td>16,277</td>
<td>Head/neck</td>
<td>0.72</td>
<td>0.61–0.85</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Face</td>
<td>1.17</td>
<td>0.99–1.38</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Thorax</td>
<td>1.86</td>
<td>1.55–2.23</td>
<td>0.065</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Abdomen</td>
<td>1.94</td>
<td>1.63–2.31</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Extremity</td>
<td>1.78</td>
<td>1.55–2.05</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td></td>
<td></td>
<td>External/burn/other</td>
<td>2.45</td>
<td>2.05–2.93</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Blood transfusion</td>
<td>2,150</td>
<td>RBC (unit increase)</td>
<td>1.01</td>
<td>1.00–1.02</td>
<td>0.08</td>
</tr>
<tr>
<td></td>
<td></td>
<td>PLT (unit increase)</td>
<td>0.97</td>
<td>0.91–1.04</td>
<td>0.45</td>
</tr>
<tr>
<td></td>
<td></td>
<td>CRYO (unit increase)</td>
<td>1.10</td>
<td>0.99–1.22</td>
<td>0.08</td>
</tr>
<tr>
<td></td>
<td></td>
<td>WB (unit increase)</td>
<td>1.03</td>
<td>1.01–1.06</td>
<td>0.01</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Plasma (unit increase)</td>
<td>1.00</td>
<td>0.98–1.01</td>
<td>0.79</td>
</tr>
<tr>
<td></td>
<td></td>
<td>RBC + WB (unit increase)</td>
<td>1.01</td>
<td>1.00–1.02</td>
<td>0.02</td>
</tr>
<tr>
<td>Massive transfusion</td>
<td>2,150</td>
<td>Yes vs. no</td>
<td>1.03</td>
<td>0.82–1.30</td>
<td>0.80</td>
</tr>
<tr>
<td>Injury year</td>
<td>16,405</td>
<td>2004 vs. 2003</td>
<td>1.13</td>
<td>0.95–1.35</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2005 vs. 2003</td>
<td>1.37</td>
<td>1.14–1.66</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2006 vs. 2003</td>
<td>0.26</td>
<td>0.20–0.35</td>
<td>0.002</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2007 vs 2003</td>
<td>0.11</td>
<td>0.08–0.17</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2008 vs. 2003</td>
<td>0.07</td>
<td>0.04–0.13</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

Massive transfusion, ≥10 units of blood product support; PLT, platelets; CRYO, cryoprecipitate; WB, whole blood.

* Overall injury pattern "univariate" model differs from model in first row by adjusting for all other known injury patterns when estimating the effect of an individual injury pattern (non-zero MAIS body region sub-score).
TABLE 9. Multivariate Analysis of Risk Factors Associated With Development of an Infection (Multiple Predictors in Logistic Regression Performed on \( n = 16,169 \); Missing Data or Lack of Record on Injury Pattern, Intensive Care, Ventilation or Blood Transfusion Presumed to Reflect Record That No Such Trauma or Hospitalization Characteristics Exist)

<table>
<thead>
<tr>
<th>Risk Factor</th>
<th>Comparison</th>
<th>Odds Ratio</th>
<th>95% Confidence Interval</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operation/yr of trauma</td>
<td>OIF 2004 vs. OIF 2003</td>
<td>1.43</td>
<td>1.16–1.76</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td></td>
<td>OIF 2005 vs. OIF 2003</td>
<td>1.36</td>
<td>1.09–1.68</td>
<td>0.006</td>
</tr>
<tr>
<td></td>
<td>2006 vs. OIF 2003</td>
<td>7.56</td>
<td>5.49–10.41</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td></td>
<td>2007–2008 vs. OIF 2003</td>
<td>17.74</td>
<td>12.11–25.98</td>
<td>0.001</td>
</tr>
<tr>
<td></td>
<td>OEF 2003–2005 vs. OIF 2003</td>
<td>1.13</td>
<td>0.77–1.67</td>
<td>0.53</td>
</tr>
<tr>
<td></td>
<td>OEF 2006–2008 vs. OIF 2003</td>
<td>1.30</td>
<td>0.65–2.62</td>
<td>0.46</td>
</tr>
<tr>
<td>Mechanism of injury</td>
<td>Blast injury vs. GSW</td>
<td>0.92</td>
<td>0.75–1.14</td>
<td>0.46</td>
</tr>
<tr>
<td></td>
<td>Burn vs. GSW</td>
<td>0.65</td>
<td>0.38–1.12</td>
<td>0.12</td>
</tr>
<tr>
<td></td>
<td>Penetrating injury vs. GSW</td>
<td>0.79</td>
<td>0.47–1.33</td>
<td>0.37</td>
</tr>
<tr>
<td></td>
<td>Blunt force injury vs. GSW</td>
<td>1.57</td>
<td>1.20–2.07</td>
<td>0.001</td>
</tr>
<tr>
<td></td>
<td>Other injury vs. GSW</td>
<td>1.36</td>
<td>0.58–3.18</td>
<td>0.48</td>
</tr>
<tr>
<td>Injury severity</td>
<td>ISS (unit increase &lt;15)</td>
<td>0.84</td>
<td>0.81–0.86</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Scale (military, maximum on record across levels of care)</td>
<td>Change in baseline risk, 15–29 vs. &lt;15</td>
<td>0.21</td>
<td>0.10–0.47</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td></td>
<td>Change in unit increase, 15–29 vs. &lt;15</td>
<td>1.15</td>
<td>1.10–1.20</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td></td>
<td>Change in baseline risk, ≥30 vs. &lt;15</td>
<td>0.04</td>
<td>0.02–0.07</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td></td>
<td>Change in unit increase, ≥30 vs. &lt;15</td>
<td>1.20</td>
<td>1.16–1.24</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Injury pattern</td>
<td>Head/neck</td>
<td>1.95</td>
<td>1.55–2.44</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td></td>
<td>Face</td>
<td>1.27</td>
<td>1.06–1.53</td>
<td>0.01</td>
</tr>
<tr>
<td></td>
<td>Thorax</td>
<td>1.00</td>
<td>0.82–1.23</td>
<td>0.97</td>
</tr>
<tr>
<td></td>
<td>Abdomen</td>
<td>0.96</td>
<td>0.79–1.18</td>
<td>0.71</td>
</tr>
<tr>
<td></td>
<td>Extremity</td>
<td>1.06</td>
<td>0.89–1.27</td>
<td>0.52</td>
</tr>
<tr>
<td></td>
<td>External/burn/other</td>
<td>0.63</td>
<td>0.51–0.77</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Transfusion</td>
<td>Massive transfusion</td>
<td>0.998</td>
<td>0.997–1.002</td>
<td>0.08</td>
</tr>
<tr>
<td>Hospital data</td>
<td>Total hospital days over 5 d (unit increase)</td>
<td>1.86</td>
<td>0.81–4.24</td>
<td>0.14</td>
</tr>
<tr>
<td></td>
<td>ICU stay (1 or more days)</td>
<td>0.999</td>
<td>0.997–1.002</td>
<td>0.74</td>
</tr>
</tbody>
</table>

GSW, gunshot wound.

anism of injury, ISS (especially higher ISS score), length of hospital stays/intervention (ICU admission, ventilation), and injury pattern. Risk factors such as transfusions are likely reflective of injury severity and pattern of injury and perhaps should be considered confounders rather than independent risk factors for infections. Although this is in contrast to other publications from OIF/OEF, overall, these risk factors are consistent with previously published studies.\(^{19,24}\) Year of injury might be reflective of total number of casualties entered into the JTTR with connected infection outcomes data, or it might be due to inherent limitations of the JTTR system which are addressed below.

Despite this being a very large and broad assessment of infectious complications of a purely US population of combat-related injuries, there remain numerous limitations in the use of these data. As previously described, the JTTR has undergone a series of improvements in data collection and entry since its conception, and it is unclear which records have been completely extracted per year for this study. This might result in discrepancies in data over time, reflective of the different methods of defining infection that we implemented in our previous review of the JTTR infectious complications.\(^{24}\) Also, the collection of Level V data has been incomplete at many facilities. Unfortunately, this is evident by the lack of outcome data for the majority of casualties and not likely reflective of the decreasing infection rate or improvements in infection prevention. This lack of late complication data might miss the importance of gram-positive, notable methicillin-resistant Staphylococcus aureus, in infections and place a greater importance on gram-negative early infections. This fact also might indirectly cause systematic data capture errors due to a focus on certain clinical records (i.e., more severe trauma patients) being extracted first lending to the possibility of bias in the data and the higher infection rates noted in the first review of the JTTR. Although the JTTR is designed as a DoD process, the JTTR has not consistently captured Level V Navy and Air Force facilities. A major improvement of the latest version of the JTTR is the implementation of a specific infectious disease module to enhance infectious disease specific data collection, which has been collecting data since June 2009. This ID module has been used by the Infectious Disease Clinical Research Program Trauma Infectious Disease Outcome Study for long-term follow-up of casualties to determine chronic combat-related injury infectious complications. These new projects should overcome the ICD-9 code limitations that prevent granularity, including the ability to capture infections with Acinetobacter or methicillin-resistant Staphylococcus aureus; pathogens which do not have unique ICD-9 codes. These improvements should also overcome the issue with
TABLE 10. Time Since Trauma Adjusted Multivariate Analysis of Risk Factors Associated With Incidence Density Rate of Infections per 100 Person-Days (Multiple Predictors in Poisson Regression Incorporating Time Since Trauma Across Levels of Care, Performed on n = 16,169; Missing Data or Lack of Record on Injury Pattern, Intensive Care, Ventilation or Blood Transfusion Presumed to Reflect Record That no Such Trauma or Hospitalization Characteristics Exist)

<table>
<thead>
<tr>
<th>Risk Factor</th>
<th>Comparison</th>
<th>Incidence Density Rate Ratio</th>
<th>95% Confidence Interval</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operation/yr of trauma</td>
<td>OIF 2004–2005 vs. OIF 2003</td>
<td>0.82</td>
<td>0.70–0.96</td>
<td>0.02</td>
</tr>
<tr>
<td></td>
<td>OIF 2006 vs. OIF 2003</td>
<td>0.33</td>
<td>0.24–0.45</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td></td>
<td>OIF 2007–2008 vs. OIF 2003</td>
<td>0.13</td>
<td>0.09–0.19</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td></td>
<td>OEF 2003–2008 vs. OIF 2003</td>
<td>0.72</td>
<td>0.52–0.98</td>
<td>0.038</td>
</tr>
<tr>
<td>Mechanism of injury</td>
<td>Blast injury vs. GSW</td>
<td>1.01</td>
<td>0.83–1.22</td>
<td>0.96</td>
</tr>
<tr>
<td></td>
<td>Burn vs. GSW</td>
<td>0.81</td>
<td>0.47–1.39</td>
<td>0.44</td>
</tr>
<tr>
<td></td>
<td>Penetrating injury vs. GSW</td>
<td>1.36</td>
<td>0.75–2.46</td>
<td>0.31</td>
</tr>
<tr>
<td></td>
<td>Blunt force injury vs. GSW</td>
<td>0.74</td>
<td>0.57–0.95</td>
<td>0.02</td>
</tr>
<tr>
<td></td>
<td>Other injury vs. GSW</td>
<td>1.13</td>
<td>0.46–2.75</td>
<td>0.80</td>
</tr>
<tr>
<td>*ISS</td>
<td>ISS (unit increase, &lt;15)</td>
<td>1.08</td>
<td>1.05–1.11</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Military</td>
<td>Change in baseline risk, 15–29 vs. &lt;15</td>
<td>1.85</td>
<td>0.95–3.59</td>
<td>0.07</td>
</tr>
<tr>
<td></td>
<td>Change in unit increase, 15–29 vs. &lt;15</td>
<td>0.94</td>
<td>0.91–0.98</td>
<td>0.003</td>
</tr>
<tr>
<td></td>
<td>Change in baseline risk, ≥30 vs. &lt;15</td>
<td>3.69</td>
<td>2.24–6.07</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td></td>
<td>Change in unit increase, ≥30 vs. &lt;15</td>
<td>0.93</td>
<td>0.90–0.95</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Injury pattern</td>
<td>Head/neck</td>
<td>0.79</td>
<td>0.65–0.95</td>
<td>0.01</td>
</tr>
<tr>
<td></td>
<td>Face</td>
<td>0.91</td>
<td>0.78–1.07</td>
<td>0.25</td>
</tr>
<tr>
<td></td>
<td>Thorax</td>
<td>1.10</td>
<td>0.93–1.29</td>
<td>0.28</td>
</tr>
<tr>
<td></td>
<td>Abdomen</td>
<td>1.01</td>
<td>0.85–1.19</td>
<td>0.92</td>
</tr>
<tr>
<td></td>
<td>Extremity</td>
<td>0.88</td>
<td>0.76–1.03</td>
<td>0.11</td>
</tr>
<tr>
<td></td>
<td>External/burn/other</td>
<td>1.31</td>
<td>1.09–1.59</td>
<td>0.005</td>
</tr>
<tr>
<td>Transfusion</td>
<td>Massive transfusion</td>
<td>1.20</td>
<td>0.98–1.46</td>
<td>0.08</td>
</tr>
<tr>
<td>Hospital data</td>
<td>Total hospital days over 5 d (unit increase)</td>
<td>0.995</td>
<td>0.994–0.996</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td></td>
<td>Total days in ICU (unit increase)</td>
<td>1.006</td>
<td>1.003–1.009</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td></td>
<td>Ventilator use (1 or more days)</td>
<td>1.49</td>
<td>1.25–1.77</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

GSW, gunshot wound.
* Maximum on record across levels of care.

connecting specific infections with body sites as it is unclear whether those with thoracic injuries are sicker with more infections or whether the infections are involving the thoracic injury itself.

This review of the JTTR provides an ongoing assessment of the challenges facing healthcare providers to control the acute and chronic infectious complications of combat casualties even though the numbers are likely an underrepresentation given the issues with Level V data collection during the study period and the lack of long-term follow-up. There are a number of limitations of the current registry that are actively being addressed through infectious disease specific data collection and analysis. Despite these limitations, these data do enable improvements in ongoing data collection. In addition, they allow for continued focus on developing improvements in patient care and future research programs. Understanding the entire combat-related injury infection epidemiology is the first step toward an evidence-based intervention program.

ACKNOWLEDGMENTS

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REFERENCES


