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Hotel Clinic-Based Diarrheal and Respiratory Disease Surveillance in U.S. Service Members Participating in Operation Bright Star in Egypt, 2009

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Abstract. We conducted clinic-based, influenza-like illness and diarrheal disease surveillance among U.S. service members participating in Operation Bright Star 2009. Epidemiologic data and samples were collected. Nasopharyngeal swab specimens were tested for viruses, and feces was tested for microbiologic, immunologic, and molecular diagnostics. A survey was used to collect self-reported data. From 1,529 surveys, 41% reported diarrheal disease and 25% reported respiratory illness (incidence rate = 62 of 100 versus 37 of 100 person-months; incidence rate ratio = 1.7, 95% confidence interval = 1.5–1.9). Enterotoxigenic *Escherichia coli* was identified in 74% (69 of 93) of fecal samples. In the influenza-like illness case series, 17% (9 of 52) were positive for influenza A; all were positive for pandemic (pH1N1) 2009 virus. Rates of decreased work performance reported by patients with diarrhea and influenza-like illness were similar (46% versus 48%; $P = 0.8$). Diarrheal diseases and respiratory illness remain common among deployed military personnel, with important operational impact. Despite an ongoing influenza pandemic, diarrheal disease incidence was higher than that of respiratory illness.

INTRODUCTION

Infectious diseases and non-battle injuries impact military operations because of loss of person-days and increase in health care use. Many successful strategies have reduced their impact through preventive measures, however infectious diseases and non-battle injuries still cause considerable morbidity, particularly in deployed settings. Acute infectious diarrhea and respiratory infections are known to be leading causes of illness among deployed U.S. military personnel in combat and noncombat operations.[1–6]

More broadly, acute infectious diarrhea is recognized as the most common illness of travelers, affecting up to 60% of short-term international travelers, with at least 20% of affected bedridden for part of their trip and 40% changing their itinerary because of diarrhea.[7] Travelers' diarrhea is also the most common medical problem for military troops deployed abroad, with an average incidence of 29% per month and an incidence of up to 60% in high-risk areas such as Southeast Asia.[8] Throughout military theaters over time, diarrhea has had important operational impact; diarrhea developed in up to 57% of troops deployed in Operation Desert Shield/Storm and 20% of the troops were temporarily unable to perform their duties because of diarrhea.[9,10] In addition, there has been increasing attention paid to the impact of viral gastroenteritis, including norovirus, which has been shown to have an operational impact during outbreaks.[11] The short-term morbidity from diarrheal illness increases health care service use, loss of human-hours, and may cause transient critical shortages in the deployed force. Meanwhile, there have been important efforts to understand more intermediate and long-term effects of diarrheal disease in a traveler population, such as the risk of post-infectious irritable bowel syndrome and other long-term sequelae.[12,13]

Respiratory illnesses are also important conditions that contribute to a large disease burden in deployed settings. Deployed military troops are at increased risk for acquiring respiratory disease, which is a threat because of historically high attack rates, rapid onset, and difficulty controlling transmission in austere environments.[14–16] With the emergence of pandemic H1N1/2009 influenza (pH1N1/2009), attack rates were particularly high among young, healthy adults compared with typical influenza seasons.[17] The first reported cases of pH1N1/2009 in the Middle East/Southwest Asia (outside Israel) were identified among U.S. soldiers deployed to Kuwait, highlighting the need to continue to perform surveillance and other studies to better define these illnesses in various operational settings across regions, to develop a full understanding of the impact of infectious diseases on the U.S. military and the general population.[18]

The Department of Defense conducts epidemiologic studies among deployed military populations to understand the incidence and impact of such illnesses, assess prevention strategies, and identify areas of risk and concern, given the complex dynamics of global military deployments. Thus, ongoing surveillance enables continued monitoring of disease trends. A military exercise held using deployed U.S. service members to the Middle East provided an opportunity to provide infectious disease surveillance in an urban, operational setting. Operation Bright Star (OBS) is a biennial, multi-national military exercise held in Egypt. The purpose of our study was to conduct real-time, clinic-based surveillance for influenza-like illness (ILI) and diarrheal disease in U.S. service members in support of force health protection efforts for OBS. In addition, we sought to collect and analyze self-reported illness data on respiratory illness, diarrheal illness, and injury by use of a post-exercise questionnaire.

MATERIALS AND METHODS

Study population, case definition, and sample collection. During September–November 2009, clinic-based surveillance was conducted for consenting U.S. service members participating in OBS. In two separate rotations of personnel

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predominantly deployed from the United States, approximately 1,550 service members residing among 11 hotels in the Greater Cairo (n = 10) and Alexandria (n = 1) metropolitan areas participated in OBS. A typical OBS participant resided in a hotel for 2–3 weeks and then departed; during this time activities were focused on table-top and/or field exercises. Temporary clinics, staffed and operated fully by U.S. military personnel were established at each of the hotels. Consenting persons meeting inclusion criteria for diarrhea were offered enrollment. Diarrhea was defined as three or more loose or liquid stools in a 24-hour period or two or more loose or liquid stools in 24 hours, associated with fever or other gastrointestinal symptoms (nausea, vomiting, cramps, tenesmus, or blood in stool). A case report form for each enrolled person was completed by the provider. Participating subjects with diarrhea were provided supplies to collect and return a stool sample to the clinic, preferably at the time of initial visit or as soon as possible before any antibiotic administration.

Because of the unique geopolitical climate in the region during the influenza pandemic in 2009, and at the request of the Egyptian Ministry of Health to pursue an aggressive approach to identify potential influenza cases (for mitigating spread of disease by isolation measures), a modified case definition for ILI was used as inclusion criteria for respiratory infection surveillance. Consenting persons with fever (temperature > 100.4°F) or reporting subjective fever and/or history of fever were considered meeting inclusion criteria. In addition, the person must have had cough and/or sore throat and symptoms must have started in the previous 72 hours. However, when the provider strongly believed that influenza was a likely cause of the illness, persons were not excluded from the analysis if symptom onset was greater than 72 hours. A case report form for each enrolled person with ILI was completed by the provider, and persons had a nasopharyngeal swab (Copan, Murrieta, CA) specimen collected in the clinic. Because of the initial uncertainty of the catchment population during planning stages of the surveillance, and a desire to estimate disease incidence (to include self-reported illness), an anonymous self-completed post-exercise survey was distributed for voluntary completion by departing service members.

Laboratory methods. Fecal samples were transported daily in clean stool cups maintained at 4°C for processing at NAMRU-3. An aliquot was placed in 10% formalin for microscopic evaluation for *Cryptosporidium* spp., *Entamoeba* spp., and *Giardia* spp. Specimens were cultured onto standard laboratory agar media for the recovery and identification of common enteric bacterial pathogens, e.g., *Shigella* spp., *Salmonella* spp., *Campylobacter* spp., *Vibrio* spp., and enterotoxigenic *Escherichia coli* (ETEC). Speciation of *Campylobacter* isolates was performed by using hippurate hydrolysis, and *Shigella* isolates were serotyped by slide agglutination using commercial antisera (Difco Laboratories, Livonia, MI). Antimicrobial sensitivity testing was conducted by using the disk diffusion method according to the guidelines of the Clinical and Laboratory Standards Institute.[19] In the event of growth on MacConkey agar, five *E. coli*-like colonies from each stool culture were frozen at –70°C until batch testing was conducted for ETEC by GM1 ganglioside enzyme-linked immunosorbent assay for enterotoxin production (heat-labile toxin [LT] and heat-stable toxin [ST]).[20] Toxin-positive isolates were then analyzed by dot-blot assay to test for 21 colonization factors (CFs).[20] Whole cell lysate prepared from a loopful of *E. coli* growth from MacConkey plates was analyzed by multiplex PCR-based testing for ETEC toxins and 20 CFs.[21] The same lysate was used for the identification of enteroaggregative *E. coli* (EAEC) by PCR as described by Schmidt and others.[22] RNA from stool samples was extracted by using commercially available kits (Qiagen, Hilden, Germany). RNA extracts were used in different sets of reverse transcription–PCRs to detect norovirus, astrovirus, adenovirus, and rotavirus.[23–25] Using commercially available kits, we used enzyme immunoassay (EIA) testing to detect adenovirus, astrovirus, rotavirus, and norovirus (IDEIA; Oxoid Ltd., Angel Drove, United Kingdom) and for detecting protozoa, *Cryptosporidium* spp., *G. lamblia*, and *E. histolytica* (Wampole, Princeton, NJ).

For respiratory samples, nasopharyngeal swab specimens were maintained at ≤ 4°C and sent daily to the NAMRU-3 laboratory, where nucleic acid was extracted and processed for influenza A subtypes H1N1, H3N2, and pH1N1/2009 by real-time polymerase chain reaction (PCR) according to standardized protocol of the Centers for Disease Control and Prevention (Atlanta, GA).[26] The PCR testing was also performed for influenza B, human parainfluenza virus 1–3, human metapneumovirus, respiratory syncytial virus, adenovirus, and atypical bacteria (*Mycoplasma pneumoniae*, *Legionella pneumoniae*, and *Chlamydia pneumoniae*).[27] The human ribonucleoprotein gene was used as an internal control (Centers for Disease Control and Prevention).

Statistical analysis. Data from all surveys and case report forms were double-data entered into an Access (Microsoft, Redmomd, WA) database. All statistical analyses were completed by using SAS Version 9.1 (SAS Institute Inc.; Cary, NC). Chi-square or Fisher's exact tests were used to determine statistical significance among discrete or categorical variables. For parametric testing of continuous variables, the *t*-test or analysis of variance was used. The Kruskal-Wallis test was used for nonparametric testing. Incidence rates and incidence rate ratios were calculated using by Poisson distributions to estimate incidence rates, and then evaluated for associations with demographic and risk behavior by using Poisson regression. This study was approved by the U.S. Naval Medical Research Unit No. 3 (NAMRU-3) Institutional Review Board in compliance with all applicable Federal regulations governing the protection of human subjects.

RESULTS

Diarrhea case surveillance. One hundred sixteen persons were enrolled during the surveillance period. Most persons were male (81%) and enlisted (72%) personnel, with a median age of 34 years (interquartile range [IQR] = 28–41 years) (Table 1). The median number of loose or liquid stools reported during the current episode to time of enrollment was six (IQR = 4–12), with a median of four loose or liquid stools during the 24-hour period before enrollment (IQR = 3–7). The median number of days in country until illness onset was four days (IQR = 2–7), with a median of one day from onset to clinic visit (IQR = 0–3). The most commonly associated symptoms were abdominal cramps (78%), nausea (57%), subjective fever (29%), and vomiting (21%) (Table 1).

Thirty-six percent of the participants reported self-treatment before their clinic visit; loperamide alone was the most common treatment (63%). At initial clinic visit, 46% reported that

Table 1

Diarrhea surveillance, demographic characteristics, clinical symptoms, treatment, and associated impact in 116 U.S. service members during Operation Bright Star, 2009*

Characteristic	Value
Demographic	
Age, years	
19–25	21 (18)
26–37	56 (48)
38–54	39 (34)
Median (IQR)	34 (28–41)
Male sex	94 (81)
Rank	
Junior enlisted	36 (31)
Senior enlisted	47 (41)
Officers	26 (22)
Warrant officers	7 (6)
Clinical symptoms on presentation	
No. loose/liquid stools since beginning of episode, median (IQR)	6 (4–12)
Abdominal cramps	89 (78)
Fever	32 (29)
Blood in feces	4 (4)
Headache	57 (50)
Joint pain	31 (27)
Nausea	66 (57)
Vomiting	24 (21)
Muscle aches	45 (39)
Treatment	
Self-medication	41 (36)
Imodium (loperamide)	26/41 (63)
Pepto Bismol (bismuth subsalicylate)	13/41 (32)
Antibiotic	6/41 (15)
Ability to work	
Diarrhea decreased ability to work	53 (46)
Days diarrhea decreased ability to work, median (IQR)	2 (1–3)
Put on bed rest because of diarrhea	22 (21)
Median no. of days in country until illness (IQR)	4 (2–7)

*Values are no. positive (%) or no. positive/no. tested (%) unless otherwise indicated. Some variables may not have been reported for all responders because of missing/illegible answers. IQR = interquartile range.

Table 3

Disribution of 52 patients with ILI according to demographic characteristics, clinical symptoms, treatment, and associated impact during Operation Bright Star, 2009*

Characteristic	Value
Age, years	
19–25	14 (28)
26–37	22 (43)
38–54	15 (29)
Median (IQR)	31 (24–38)
Male sex	43 (65)
Rank	
Junior enlisted	17 (33)
Senior enlisted	23 (44)
Officers	9 (17)
Warrant officers	3 (6)
Days since illness onset, median (IQR)	2 (1–4)
Median duration (days) between arrival and onset of illness (IQR)	6 (2–10)
History of asthma	8 (16)
Currently smoking	10 (19)
Received influenza vaccine in past 12 months	46 (90)
Clinical symptoms at presentation	
Documented fever	1 (2)
Subjective fever	36 (69)
Sore throat	32 (62)
Cough	39 (75)
Shortness of breath/difficulty breathing	10 (19)
Nasal congestion	40 (77)
Headache	34 (65)
Conjunctivitis	3 (6)
Body aches	27 (52)
Nausea or vomiting	11 (21)
Diarrhea	15 (29)
Ability to work	
Illness decreased ability to work	25 (48)
Days of decreased ability to work, median (IQR)	2 (1–2)
Put on bed rest because of illness	13 (27)
Other unit member(s) with same illness	25 (58)
Went outside unit location during the past 5 days	21 (40)

*Values are no. positive (%) unless otherwise indicated. IQR = interquartile range. No significant differences were detected between pH1N1/2009 influenza ILI cases and non-influenza ILI cases.

the symptoms had already decreased their ability to work for a median of two days (IQR = 1–3). At time of presentation, 21% were put on some form of bed rest for their symptoms.

Fecal samples were received and tested from 93 (80%) of the enrolled persons. Of these persons, 74 (80%) of 93 had one or more pathogens recovered. Enterotoxigenic *E. coli* was the most common pathogen, identified in 69 (74%) of the participants by PCR. Enzyme immunoassay identified ETEC in 46 cases. Enterotoxigenic *E. coli* was detected as a sole pathogen in 51 (55%) persons, and was detected as a mixed infection in 18 (19%) persons (Table 2). Enteroaggregative *E. coli* was the most common co-pathogen associated with ETEC and was identified in 10 (56%) of 18 ETEC mixed infections (representing all EAEC mixed infections). Enteroaggregative *E. coli* was identified as sole pathogen in only 3 (3%) persons. A single case of *Campylobacter* spp. infection was identified as sole infection, and single cases of *Shigella* spp. and *Salmonella* spp. infection were identified, each as a mixed infection with rotavirus and ETEC, respectively. Rotavirus was not detected as a sole pathogen in any cases. Norovirus was detected only in one case as a sole pathogen and in one case as a mixed pathogen (with ETEC). No stool sample was positive for pathogenic parasites by microscopy. An EIA for parasites identified a single case of *Cryptosporidium* spp. infection and a case of *E. histolytica* infection; both cases were identified as mixed infections (with ETEC).

In regards to ETEC toxins, ST+ ETEC alone was most common, identified in 47 (68%) of ETEC cases. A combination of LT/ST+ ETEC was seen in 13 (19%), and LT+ ETEC was detected in 9 (13%) of ETEC cases. A known CF was detected in 40 (58%) of 69 ETEC cases; CS6 was most commonly seen in 17 (43%) of 40 cases. Of the CS6 ETEC cases

Table 2

Distribution of single and mixed pathogens detected from 93 samples collected during Operation Bright Star, 2009*

Pathogen	Single, no. (%)	Mixed, no. (%)
ETEC†	51 (55)	18 (19)
EAEC†	3 (3)	10 (11)
Shigella	0 (0)	1 (1)
Campylobacter	1 (1)	0 (0)
Salmonella	0 (0)	1 (1)
Cryptosporidium‡	0 (0)	1 (1)
Entamoeba histolytica‡	0 (0)	1 (1)
Norovirus‡	1 (1)	1 (1)
Rotavirus‡	0 (0)	6 (6)

*Only 93 of 116 enrolled respondents submitted fecal samples. ETEC = enterotoxigenic *Escherichia coli*; EAEC = enteraggregative *E. coli*.

†Polymerase chain reaction (PCR) results: 46 cases of ETEC were detected by enzyme immunoassay (EIA) and PCR.

‡EIA results: Rotavirus and norovirus results were detected by EIA, but were not confirmed by PCR.

detected, 76% were associated with ST only and 18% with LT only, and only one case of LT/ST+ CS6 ETEC was detected.

Case surveillance for ILI. Fifty-two patients were enrolled during the surveillance period by using the modified ILI definition. Most persons were male (65%) and enlisted (77%) personnel, and with a median age of 31 years (IQR = 24–38 years). Most (90%) had received seasonal (2009) influenza vaccination within 12 months before the exercise. Of these persons, 92% received the vaccine within the last month before OBS deployment (Table 3). The median number of days in country until illness onset was six days (IQR = 2–10 days). The median duration from symptom onset to the clinic visit was two days (IQR = 1–4 days). Only one person had documented fever, and 69% (36 of 52) had subjective fever. Cough and nasal congestion were the most commonly associated symptoms (75% and 77% of persons, respectively); 62% reported a sore throat and 29% reported diarrhea (Table 3). At initial clinic visit, 48% reported that the symptoms had already decreased their ability to work for a median of two days (IQR = 1–2 days). At time of presentation, 27% were put on some form of bed rest for their symptoms.

Table 4

Descriptive characteristics of post-exercise survey for diarrhea/vomiting, respiratory illness, and injury (n = 1,529) during Operation Bright Star, 2009*

Characteristic	Value
Age, median (IQR)	33 (25–42)
Male sex	1,212 (80)
Diarrhea/vomiting illness	
Diarrhea during deployment	631/1,529 (41)
Vomiting during deployment	104/1,529 (7)
Median duration (days) of diarrhea/vomiting illness (IQR)	3 (2–5)
Had fever with diarrhea/vomiting	88/650 (14)†
Visited sick call for diarrhea/vomiting	258/650 (40)†
Decreased work performance becasuse of diarrhea/vomiting	148/650 (23)†
Members of unit sick with diarrhea/vomiting	839 (57)
Respiratory illness	
Respiratory illness during deployment	377/1,520 (25)
Had fever, muscle aches or headache associated with the illness	138/377 (37)
Median duration (days) of respiratory illness (IQR)	3 (2–5)
Visited sick call for respiratory illness	137/374 (37)
Decreased work performance because of respiratory illness	75/377 (20)
Other member(s) sick with same symptoms	432 (30)
Injury	
During deployment	62/1,525 (4)
Type of injury	
Sprain/strain	31 (55)
Bruise/contusion	17 (30)
Laceration /open wound	7 (13)
Burn	1 (2)
Mechanism of injury	
Heavy gear lifting	30 (65)
Fall	7 (15)
Machinery/tools	2 (4)
Sports/athletics	4 (9)
Vehicle accidents	3 (7)
Median duration (days) of injury (IQR)	3 (2–5)
Visited sick call for injury	27/61 (44)
Injury decreased work performance	8/61 (13)

*Values are no. positive (%) or no. positive/no. tested (%) unless otherwise indicated. IQR = interquartile range.
†Some variables may not have been reported for all responders because of missing/illegible answers.

Of the 52 case-patients, 9 (17%) were positive for pH1N1/2009; no other seasonal influenza (A or B), or any co-pathogens were identified in influenza case-patients. Two (4%) cases of parainfluenza infection, 1 case of human metapneumovirus infection, and 1 case of adenovirus infection were detected. There were no specific symptoms or other variables (Table 3), including receiving seasonal influenza vaccine within the past 12 months before the exercise, that were statistically associated with diagnosis of influenza and pH1N1/2009 versus non-influenza ILI cases.

Post-exercise survey. A total of 1,529 service members completed the survey, representing approximately 99% of the eligible OBS surveillance participants. Because of logistical constraints with departures, some persons were not offered the opportunity to complete the survey, including a 950-service member unit that participated in OBS exercises but were generally excluded from hotel clinic access and case surveillance because they resided on ships. Data on self-reported diarrheal illness, respiratory illness, and injury were collected, as defined by the person completing the survey. Survey responders had a median age of 33 years and 80% were male (Table 4).

Self-reported diarrhea/vomiting. During OBS, 41% (n = 631) of responders reported at least one episode of diarrhea, and 7% reported vomiting (Table 4). On the basis of self-reported diarrheal episodes and person-time of deployment we calculated an overall diarrhea illness incidence rate (IR) of 62 cases/100 person-months (95% confidence interval [CI] = 60–65). Of those who experienced diarrhea, 40% sought care for their symptoms. The estimated clinic visit incidence for diarrheal illness was 25 cases/100 person-months (95% CI = 22–28).

Fourteen percent of responders with a history of diarrhea reported a fever with their symptoms. The median duration of illness was three days (IQR = 2–5 days), 23% reported decreased work performance for at least one day because of diarrheal illness, and 57% reported that members of their unit also had diarrheal illness at some point.

It was difficult to assess the frequency of food consumption from non-military sources because some meals were military rations (i.e., meals ready-to-eat), and within the same day, many persons ate at hotel breakfast or dinner buffets. In addition, for those completing the survey, 65% reported eating at a restaurant at some point during the exercise. Table 5 describes Poisson univariate analysis for factors associated with overall self-reported and clinic visit incidence of diarrhea. Reporting other members in same unit sick was associated with self-reported or clinic visit-associated diarrhea (incidence rate ratio [IRR] = 5.6, $P < 0.0001$ and IRR = 7.8, $P < 0.0001$), as was eating in a restaurant off hotel premises. The consumption of salad/uncooked vegetables was weakly associated with self-reported diarrheal illness (IRR = 1.3, $P = 0.004$), but not with clinic visit-associated diarrhea (IRR = 1.2, $P = 0.3$). Consumption of other categories of food from non-military sources, such as salad and uncooked vegetables, noncarbonated beverages, beef, and fish, was associated with self-reported diarrheal illness, but not with clinic visit-associated diarrhea (Table 5).

Self-reported respiratory illness. During OBS, 25% (n = 377) of responders reported a respiratory illness (Table 4). On the basis of self-reported respiratory illness episodes and person-time of deployment, we calculated an overall respiratory illness IR of 37 cases/100 person-months (95% CI = 34–40). Of persons who experienced a respiratory illness, 37% sought care

Table 5
Assessment of factors associated with overall and clinic visit incidence of diarrhea post-exercise survey (n = 1,529) during Operation Bright Star, 2009*

Characteristic	All diarrhea cases, IRR (95% CI)	Clinic visit-associated diarrhea cases, IRR (95% CI)
Age, years		
18–25	1.1 (0.8–1.3)	0.8 (0.5–1.1)
26–32	1.2 (1.0–1.5)	1.0 (0.7–1.4)
33–41	1.2 (1.0–1.5)	1.1 (0.8–1.6)
42–65	1 (Reference)	1 (Reference)
Female sex	0.9 (0.8–1.1)	1.0 (0.8–1.4)
Members of unit sick with diarrhea/vomiting	5.6 (4.4–7.2)†	7.8 (4.5–12.1)†
Went off base during exercise	0.7 (0.5–0.9)‡	0.5 (0.3–0.9)‡
Food or drink from non-U.S. military sources	1.5 (1.2–1.8)§	1.7 (1.2–2.3)¶
Salad/uncooked vegetables	1.3 (1.1–1.5)¶	1.2 (0.9–1.5)
Cooked vegetables/rice	1.8 (1.3–2.4)§	1.7 (1.1–2.6)‡
Noncarbonated beverage	1.3 (1.1–1.5)¶	1.3 (0.9–1.6)
Chicken	1.3 (0.9–1.7)	1.7 (1.0–3.0)
Fish	1.3 (1.1–1.5)	1.2 (0.9–1.6)
Lamb	1.4 (1.2–1.7)†	1.3 (1.1–1.7)#
Beef	1.6 (1.2–2.1)¶	1.3 (0.9–2.1)

*IRR = incident rate ratio; CI = confidence interval.
† $P \leq 0.0001$.
‡ $P \leq 0.05$.
§ $P \leq 0.001$.
¶ $P \leq 0.01$.
# $P = 0.05$.

for their symptoms. The estimated clinic visit incidence for respiratory illness was 14 cases/00 person-months (95% CI = 11–16). Of persons reporting respiratory illness, 37% reported fever, muscle aches, or headache associated with the illness and 20% reported decreased work performance for at least one day because of the illness. The median duration of respiratory illness was 3 days (IQR = 2–5 days). Thirty percent of responders with a self-reported respiratory illness reported that other members in their unit were also ill with similar symptoms.

Self-reported injury. During OBS, 4% reported an injury (IR = 6 cases/00 person-months; 95% CI = 5–8). Of those injured, 44% went to clinic for the injury, and the estimated clinic visit incidence for injury was 3 cases/00 person-months (95% CI = 2–4). Of the type of injury, 55% reported a sprain/strain, 30% reported a bruise/contusion, and 13% reported a laceration/open wound. Heavy gear lifting was the most common mechanism of injury (65%), followed by fall (15%). Nine percent were injured during athletic activities (Table 4).

Table 6
DNBI rates reported during Operation Bright Star, 2009, by study week*

DNBI category	Week 1	2	3	4	5	6	7
Combat stress reaction	0.0	0.0	0.1	0.0	0.0	0.0	0.0
Dermatologic	0.0	2.5	2.8	2.8	1.6	2.9	0.0
Gastrointestinal, infectious	4.0	10.5	13.7	13.3	6.1	4.1	0.0
Gynecologic	0.0	0.7	1.4	2.4	0.6	0.0	0.0
Injury (total)	0.0	0.8	0.9	1.1	1.5	2.4	0.0
Heat/cold injuries	0.0	0.1	0.0	0.0	0.0	0.0	0.0
Injury, sports/recreation	0.0	0.0	0.0	0.3	0.1	0.0	0.0
Injury, motor vehicle accident	0.0	0.0	0.0	0.0	0.2	0.8	0.0
Injury, work/training	0.0	0.3	0.6	0.2	0.8	0.4	0.0
Injury, other	0.0	0.2	0.3	0.6	0.4	1.2	0.0
Ophthalmologic	0.0	0.2	0.4	0.5	0.3	0.4	0.0
Psychiatric/mental disorders	0.0	0.0	0.0	0.0	0.1	0.8	0.0
Respiratory	2.2	5.3	9.3	12.8	4.9	4.5	12.5
Sexually transmitted disease	0.0	0.0	0.1	0.0	0.0	0.0	0.0
Fever, unexplained	0.0	0.1	0.3	0.2	0.0	0.0	0.0
All other	1.1	5.5	6.3	8.4	4.8	2.4	0.0

*DNBI = disease and non-battle injury.

Diseases and non-battle injury statistics. Clinic statistics were maintained independent of surveillance activities and clinic visits were coded by using standard diseases and non-battle injury (DNBI) categories and statistics. These categories and values were compiled on a weekly basis for 6.5 weeks during September 27–November 2, 2009 (Table 6). Gastrointestinal infections were the most common category of DNBI, which peaked during weeks three and four of the operation and coincided with a time of personnel rotation. The overall incidence rate/100 person-total exercise duration was 51.8 for gastrointestinal infections, 51.4 for respiratory illness, and 6.5 for injury.

DISCUSSION

Diarrhea and respiratory illness remain common among deployed military personnel, resulting in important operational impact. This study had a focus on real-time surveillance, particularly for ILI, because of geopolitical concerns regarding pandemic influenza. Our case-based surveillance was focused on understanding the etiology of infectious diarrhea and respiratory infections, and we also used a post-exercise survey to estimate the incidence of self-reported diarrheal illness, respiratory illness, as well as injury and their associated impact. In addition, we compared incidence rate to DNBI surveillance data. Because this exercise is conducted every two years, and when possible using similar study tools, it also affords the opportunity to examine illness trends over time. We have shown that passive surveillance significantly underestimates the incidence of diarrheal and respiratory illnesses.

In OBS, the incidence of diarrhea was higher than that of respiratory illness, despite the more significant awareness of influenza-like illness from pandemic H1N1/2009. On the basis of the post-exercise survey, we estimated an overall self-reported diarrheal illness monthly incidence rate of 62 cases/00 person-months, which is higher than previous OBS exercises and also higher than other recent incidence rates published in a systematic review of diarrhea incidence among recently deployed US troops in Iraq, Kuwait, and Afghanistan.[4,28,29] Part of this incidence could be caused by shorter rotations and presumed accompanying time for a disease-free period because it is known that diarrheal illness can manifest early after arrival into a disease-endemic region. However, this exercise was unique in that service members resided in urban hotels and had broad food (and environmental) exposures ranging from hotel buffets, occasional field rations (meals ready-to-eat), to eating away from hotel premises. In addition, service members were often bused daily to a base where table-top exercises were completed, enabling more crowding of personnel. In previous OBS exercises and in other studies of operational military personnel (such as in Iraq, Kuwait, and Afghanistan), local food exposures were more limited, lessening the risk of diarrheal illness.

In this exercise, 40% of persons who self-reported a history of diarrhea or vomiting visited the clinic for the illness (clinic visit incidence rate of 6 visits person-week; 25 cases/00 person-months), compared with 20% from a previous OBS exercise (clinic visit incidence of 1.8 visits for diarrheal illness per 100 person-weeks).[4,29] The increased rate of seeking care could have been partially caused by increased service member awareness of the benefits of seeking treatment for diarrheal illness in addition to the increased availability and convenience of medical care. This exercise was unique in that clinics were established within each hotel where service members resided. From our comparative data, the severity of diarrhea was not greater in the current exercise at time of presentation. Therefore, we believe that this increased proportion of clinic visits was not likely caused by more severe symptoms. In this exercise, the mean duration from onset of symptoms of diarrheal illness to clinic visit was one day (IQR = 0–3 days). For persons with ILI symptoms, the median duration was two days (IQR = 1–4 days). The rate of seeking care for a self-reported diarrheal illness or respiratory illness was similar (40% versus 37%; P = 0.3). The importance of diarrhea and respiratory illness and their potential for impacting the mission is recognized by service members. A general polling question from the post-exercise survey demonstrated that 34%, 23%, and 14% of service members identified that diarrheal illness, respiratory illness, and injury, respectively, would have affected mission operation and capabilities.

It is important to note the benefit of enhanced awareness or availability of clinical care for diarrheal illness, and other infectious diseases, such as influenza. First, early recognition of infectious diseases and their trends in an operational setting may enable steps to be taken to mitigate spread, such as by isolation, placement of sick-in-quarters, and other public health mitigation efforts. In addition, it affords an opportunity to provide curative treatment earlier in course of illness, lessening the impact of illness on individual readiness and the operational team because early treatment also translates to shorter time of a person being contagious. This finding is true for diarrheal illness in an operational setting, in which there have been efforts to enhance awareness of antibiotic treatment and to use antibiotics earlier in the course of illness.[30]

The rates of decreased work performance reported by persons with diarrhea and ILI were similar (46% versus 48%; P = 0.8). The most common cause of ILI was pH1N1/2009. The modified ILI definition may have captured other respiratory illnesses (including noninfectious illnesses) because documented fever was not required to meet case definition. Regardless, the strict screening criteria (and resulting mitigation plan for confirmed cases) allayed concerns from local authorities regarding significant spread of pH1N1/2009 from U.S. service members into the local community, where aggressive public health countermeasures were in place. This approach afforded the opportunity to conduct the exercise during the time of a sensitive geopolitical climate.

ETEC remains the most commonly detected diarrheal pathogen in this population, which highlights the important role ETEC plays in the diarrheal disease burden among travelers (and deployed service members) in this region and in other areas of the world.[31–33] ETEC is a target pathogen for Department of Defense enteric vaccine efforts because of its significant burden of illness associated with travelers throughout the world.[34] Infectious disease surveillance in military populations across various operational settings and regions provides a unique opportunity to develop a full understanding of the etiologies, trends (including molecular epidemiology), and impact of infectious disease threats to inform vaccine development and other preventive efforts.

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