AUGUST 2020

Volume 27
Number 08

MSMR

MEDICAL SURVEILLANCE MONTHLY REPORT

CDC/Antibiotic Resistance Coordination and Strategy Unit

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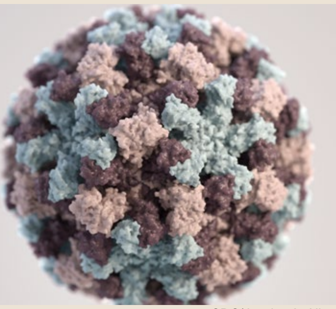

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CDC/Antibiotic Resistance Coordination and Strategy Unit

A publication of the Armed Forces Health Surveillance Branch

Commentary: The Limited Role of Vaccines in the Prevention of Acute Gastroenteritis

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Acute gastroenteritis is associated with sudden onset of disturbances in gastrointestinal function such as nausea, vomiting, diarrhea (sometimes bloody), abdominal cramps, and fever. The illness typically lasts less than 2 weeks and is most commonly associated with an infectious etiology. Treatment with antibiotics and antimotility agents may be indicated depending upon the causative infectious agent and the severity of symptoms. Acute gastroenteritis is very common and is estimated to cause 179 million cases, over 470,000 hospitalizations, and over 5,000 deaths among U.S. residents each year.[1] People usually acquire the infectious agents (bacteria, viruses, or protozoa) via the ingestion of contaminated food or water or direct person-to-person contact. Although developed nations have reduced the risks of exposure to gastrointestinal pathogens by building infrastructures of sanitary systems for water distribution and sewage disposal, transmission via contaminated food and water remains common.

In military populations, the threat of gastroenteritis is enhanced when personnel are serving in field settings as part of training, deployment, or in theaters of combat. The efforts of military preventive medicine and environmental health assets focus on minimizing the risks of foodborne and waterborne disease not only in the peacetime settings of congregate housing and field training but also in the austere settings of combat. Although such preventive measures are effective, they do not prevent all gastrointestinal illness.

Immunizations provide a powerful class of defense against infectious diseases. Although vaccines protecting against at least 30 different infectious diseases have been approved by the U.S. Food and Drug Administration (FDA) on the basis of evidence of safety and effectiveness, only 2 of those vaccines (cholera, rotavirus) offer the prospect of an immunological defense against a specific cause of gastroenteritis.[2]

The FDA-approved cholera vaccine is a live, orally administered vaccine that offers protection against the *Vibrio cholerae* O1 strain, a bacterium capable of causing gastroenteritis at the more severe end of the spectrum (i.e., cholera).[3] Cholera vaccine is not a routinely administered vaccine, and no country or territory currently requires vaccination against cholera as a condition of entry for visitors. The Advisory Committee for Immunization Practices and the Centers for Disease Control and Prevention recommend cholera vaccine for individuals 18–64 years of age who reside in an area with endemic cholera or who will travel to an area that is experiencing a cholera outbreak or that has a high risk of cholera because of a humanitarian crisis.[3] There are also 3 other oral vaccines for cholera that are not approved for use in the U.S. These vaccines are killed vaccines and they require 2 doses at least a week apart for full protection.[3]

Rotavirus-caused gastroenteritis affects nearly all children by the time they reach the age of 5 in both developed and underdeveloped regions around the world.[4] The live, oral vaccine must be given in 2 or 3 doses, depending upon the brand of vaccine used. The first dose should be administered before 14 weeks and 6 days of age and the last dose by 8 months and 0 days of age. The vaccine is not indicated for adults.[5]

The better-recognized bacterial species associated with gastroenteritis are members of the genera *Escherichia, Salmonella, Shigella, Campylobacter, Clostridium, Staphylococcus, Bacillus, Yersinia,* and *Vibrio*. Except for *V. cholerae*, there are no vaccines for any of these bacteria. Protozoan causes of gastroenteritis are less commonly identified than the bacterial and viral causes, but there are no vaccines for the more common protozoans (i.e., *Giardia, Cryptosporidium,* and *Cyclospora*). There are numerous viral causes of gastroenteritis, but the best known are the caliciviruses (including noroviruses), astroviruses, and rotaviruses. Except for the rotavirus vaccine, there are no FDA-approved vaccines to protect against the viral causes of acute gastroenteritis. It has been estimated that noroviruses are the cause of about one-third of all cases of gastroenteritis in the U.S., so an efficacious norovirus vaccine has been the subject of much research to date.[6] The quest for a norovirus vaccine or vaccines has proven especially challenging because of the relatively short period of immunity following a clinically significant infection, the heterogeneity of strains of norovirus, and the inability to culture the virus in the laboratory.[6] Despite these challenges, several norovirus vaccine candidates are currently being evaluated in human clinical trials, including a study of a bivalent vaccine in military recruits.[7]

The incidence rates of most types of acute infectious gastroenteritis are not susceptible to reduction by vaccines. The prevention of gastroenteritis (and other diseases) spread through fecal contamination of water, food, or fomites depends upon diligent implementation of the wide spectrum of measures that constitute sanitation, hygiene, environmental health, food safety, and disease surveillance. Responsibilities in these areas fall to government agencies, suppliers of food and water, educators, public health authorities, healthcare providers, parents, and individuals.

A current review of required immunizations for Department of Defense personnel by Combatant Command is available at https://health.mil/Military-Health-Topics/Health-Readiness/Immunization-Healthcare/Vaccine-Recommendations/Vaccine-Recommendations-by-AOR.

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MSMR's Invitation to Readers

Medical Surveillance Monthly Report (MSMR) invites readers to submit topics for consideration as the basis for future *MSMR* reports. The *MSMR* editorial staff will review suggested topics for feasibility and compatibility with the journal's health surveillance goals. As is the case with most of the analyses and reports produced by Armed Forces Health Surveillance Branch staff, studies that would take advantage of the healthcare and personnel data contained in the Defense Medical Surveillance System (DMSS) would be the most plausible types. For each promising topic, Armed Forces Health Surveillance Branch staff members will design and carry out the data analysis, interpret the results, and write a manuscript to report on the study. This invitation represents a willingness to consider good ideas from anyone who shares the *MSMR*'s objective to publish evidence-based reports on subjects relevant to the health, safety, and well-being of military service members and other beneficiaries of the Military Health System (MHS).

In addition, the *MSMR* encourages the submission for publication of reports on evidence-based estimates of the incidence, distribution, impact, or trends of illness and injuries among members of the U.S. Armed Forces and other beneficiaries of the MHS. Information about manuscript submissions is available at www.health.mil/MSMRInstructions.

Please email your article ideas and suggestions to the *MSMR* Editor at dha.ncr.health-surv.mbx.msmr@mail.mil.

Diarrhea and Associated Illness Characteristics and Risk Factors Among British Active Duty Service Members at Askari Storm Training Exercise, Nanyuki, Kenya, January–June 2014

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Travelers' diarrhea (TD) has historically been common among deployed military personnel and remains a leading infectious disease threat to this population. The risk factors, work performance, and illness associated with TD among British active duty service members exercising at British Army Training Unit Kenya (BATUK) were assessed. Members of the British Army who were finishing a 6-week combined arms training exercise in Nanyuki, Kenya, completed routine public health surveillance questionnaires. Survey data included information on demographics, rank, risk factors, illness characteristics, and impact on performance. Among 1,227 survey respondents, 21.9% (n=269) reported having diarrhea, with an estimated 824 days of total missed work and 1,215 days of work underperformance. The majority of cases (54.6%) had multiple diarrheal episodes. One quarter (24.9%) of the respondents with TD sought medical care and 19.7% were bedded down because of their illness. There were no statistically significant differences between the TD and no TD groups on the demographic characteristics examined. The strongest risk factor for diarrhea was having a colleague with diarrhea (adjusted odds ratio=51.78; 95% confidence interval: 29.44–91.06). TD had a notable impact on duty status and operational capability. Efforts are needed to improve BATUK's participant education on the importance of diarrheal disease prevention and management.

WHAT ARE THE NEW FINDINGS?

This is the first report of the effect of infectious diarrhea on British troops participating in the Askari Storm Training Exercise in Nanyuki, Kenya. These data highlight the impact of diarrheal diseases in this training exercise and the continued need to refine primary prevention strategies.

WHAT IS THE IMPACT ON READINESS AND FORCE HEALTH PROTECTION?

In 2019, the National Center for Medical Intelligence identified bacterial diarrhea disease as the number one priority among endemic and emerging infectious diseases that pose a threat to deployed U.S. forces. These data support the importance of diarrheal disease in training exercises in addition to operational settings.

Travelers' diarrhea (TD) is typically defined as 3 or more unformed stools in 24 hours with at least 1 of the following additional symptoms: fever, nausea, vomiting, abdominal cramps, tenesmus, or bloody stools.[1] TD has been the most common medical problem and remains one of the most important health threats among globally deployed military members, both in combat and peacetime missions.[2,3] Infectious gastroenteritis was identified as 1 of the top 5 reasons for clinic visits in studies evaluating disease and non-battle injury rates in recent peacetime and combat operational settings.[4] While TD typically spontaneously resolves within 3 to 5 days,[5] it can have detrimental long-term consequences including functional bowel disorders, reactive arthritis, and Guillain-Barré syndrome.[6,7]

The most recent systematic review of TD in military (and similar) populations estimated more than 35 cases per 100 person-months with significant heterogeneity in incidence depending on region and duration of travel.[5] Studies of the etiology of TD in military populations point to the importance of diarrheagenic *Escherichia coli*, in particular enterotoxigenic *E. coli*, as well as other bacterial etiologies as key pathogens. TD significantly impacts affected individuals with up to 1 in 5 personnel being incapacitated or being placed sick in quarters (SIQ)[5] and a high proportion of those affected experiencing prolonged decreases in job performance.[8]

In addition to high rates of TD in operational settings, prior studies have highlighted elevated rates during military training exercises.[9–12] Data for the current study were obtained from members of the British Army who completed a 6-week combined arms training exercise based at British Army Training Unit Kenya (BATUK), a permanent training support unit located 200 kilometers north of Nairobi in Nanyuki, Kenya. BATUK consists of approximately 200 permanent and short-tour staff. BATUK provides logistical support to visiting units and, through an agreement with the Kenyan Government, facilitates six-week exercises for up to 6 infantry battle groups (1,000–1,200 troops) per year.[9] In addition, BATUK hosts Royal Engineer Squadron exercises that carry out civil engineering projects and a medical company group deployment that provides outreach primary healthcare assistance to the civilian community in collaboration and coordination with the regional and local Kenyan Health authorities.

METHODS

Study design

This was a cross-sectional study of TD among UK Army Infantry Battle Groups participating in training exercises at BATUK training camp between January and June 2014. Data were collected as part of routine public health surveillance from 1 of 3 battle groups of military personnel participating in the Askari Storm training exercise. These 6-week exercises involved a light infantry battle group operating over the rugged terrain of the Kenya savannah, including river crossings and water exposure at an altitude of 800–1,500 meters. Soldiers largely lived in the field in bivouacs and returned to camp accomodation 2–3 times during an exercise. Food and water on exercise were provided from ration packs or prepared by military chefs, with oversight from the military environmental health team. There were typically opportunities at the end an exercise for individuals and groups to take part in outdoor training activities that included kayaking and other water-based activities. During such activities, food was provided from Kenyan sources and there was fresh water exposure. During the training exercise, soldiers had opportunities to eat at Kenyan restaurants local to the base. These restaurants were inspected by the military environmental health team and required to meet UK food hygiene standards in order to appear on the approved list; however, enforcement of these regulations sometimes proved challenging.

Participants completed a survey consisting of 28 questions that collected information on respondent demographic characteristics, illness characteristics, impact of illness on work performance, and potential risk factors for TD. The questionnaires were designed for ease of use and simplicity of understanding. To facilitate data analysis, the questionnaire allowed few options for free text entries. To obtain information on illness characteristics, respondents were asked to indicate the number of different diarrheal episodes experienced and to describe the number of bowel movements from their self-assessed worst diarrheal episode. To determine the impact of TD on work performance, respondents were asked about their ability to perform their normal duties during an average episode of diarrhea and the total number of days of work missed as a result of TD. No personally identifiable information was collected at any point during the surveillance exercise.

Data sources

All UK Army Infantry Battle Group personnel participating in the 6-week Askari Storm training exercise were asked to complete routine self-administered public health surveillance paper questionnaires. Respondents were members of 1 of 3 separate battle groups (selected at random) of approximately 1,000 personnel each. Questionnaires were distributed by BATUK staff and completion was voluntary and anonymous. No data were obtained on personnel who did not complete the questionnaire. Survey data were entered into a Microsoft Access database (2010, Microsoft Corporation, Redmond, WA) by a trained data manager. Institutional review board approval was not required as per the Ministry of Defence Research Ethics Committee guidelines.

Statistical analysis

Self-reported data on demographic characteristics, potential risk factors, and diarrhea illness characteristics were summarized. Demographic comparisons between those with and without diarrhea were made using a Pearson's chi-square test. Separate logistic regression models were used to calculate odds ratios (ORs) and associated 95% confidence intervals (CIs) for each potential TD risk factor. For those potential risk factors with statistically significant ORs, adjusted odds ratios (AORs) were calculated from a multivariable logistic regression model that included all potential risk factors. All statistical analyses were performed using SAS/STAT software, version 9.3 (2011, SAS Institute, Cary, NC).

RESULTS

Study population

A total of 1,227 British Army military personnel who participated in the training exercise at the BATUK Askari Storm training camp completed public health surveillance questionnaires **(Table 1)**. Given that each battle group had approximately 1,000 military members, an approximate estimate of the size of the group from which the sample population was drawn was 3,000, for an estimated response rate of about 41%. Survey respondents were predominantly male (89.1%), between the ages of 20–25 years old (38.0%) and of the "Private" rank (45.8%). A total of 21.9% of the respondents reported having diarrhea; there were no statistically significant differences between the TD and no TD groups on the demographic characteristics examined **(Table 1)**.

The majority of respondents with diarrhea (n=147; 54.6%) reported having multiple

TABLE 1. Demographic and military characteristics of survey respondents, active duty British military personnel participating in the British Army training unit 6-week exercise Askari Storm, Nanyuki, Kenya, January–June 2014

	Total		No. with TD		No. without TD		
Characteristic	No.	%	No.	%	No.	%	p-value
Total	1,227	100.0	269	21.9	958	78.1	
Sex							
Males	1,093	89.1	240	89.2	853	89.0	.475
Females	84	6.9	21	7.8	63	6.6	
Not reported	50	4.1	8	3.0	42	4.4	
Age group (years)							
<20	138	11.3	24	8.9	114	11.9	.278
20–25	466	38.0	107	39.8	359	37.5	
26–30	338	27.6	75	27.9	263	27.5	
31–40	210	17.1	51	19.0	159	16.6	
>40	28	2.3	7	2.6	21	2.2	
Not reported	47	3.8	5	1.9	42	4.4	
Rank							
Private	562	45.8	117	43.5	445	46.5	.248
Junior non-commissioned officer	412	33.6	87	32.3	325	33.9	
Senior non-commissioned officer	122	9.9	28	10.4	94	9.8	
Warrant officer	26	2.1	5	1.9	21	2.2	
Officer	99	8.1	29	10.8	70	7.3	
Not reported	6	0.5	3	1.1	3	0.3	

No., number; TD, travelers' diarrhea.

individual diarrheal episodes, and more than one-third (34.6%) of affected respondents had a diarrheal illness that lasted for more than 3 days **(Table 2)**, leading to a total of 824 days of missed work **(data not shown)**. During their worst diarrheal episode, 50.2% of TD cases reported 3–5 stools a day, with almost a quarter (23.9%) reporting more than 5 stools daily. Concurrent symptoms included abdominal pain or cramps (63.9%), nausea or vomiting (19.0%), subjective fever (13.4%), joint pain (5.6%), and muscle aches (2.2%). Only a quarter (n=67; 24.9%) of the respondents with TD sought care and 19.7% were "bedded down" because of their illness **(Table 2)**.

Results of bivariate analyses suggested that significant risk factors for TD included having a colleague with diarrhea (OR=63.75; 95% CI: 36.51–111.33), consumption of locally sourced/produced food within 2 days before diarrhea onset (OR=3.47; 95% CI: 2.58–4.68), swimming/bathing/patrolling through local water within 3 days before diarrhea onset (OR=2.72; 95% CI: 2.03–3.63), prior appendectomy (OR=2.29; 95% CI: 1.36–3.86), and consumption of uncertified water (OR=1.60; 95% CI: 1.07–2.38) **(Table 3)**. In a multivariable model including all potential risk factors, only the consumption of locally sourced/produced food (AOR=2.00; 95% CI: 1.08–3.72) and having a colleague with diarrhea (AOR=51.78; 95% CI: 29.44–91.06) remained statistically significant.

EDITORIAL COMMENT

Accurate estimates of the burden of disease in different geographical settings and types of activities assist with military planning. The results of this study highlight the continued importance of TD in this population. In this self-selected sample of a military population engaged in a training exercise, TD increased the number of duty days lost and subsequently reduced the full benefit of the training exercise. The proportion of respondents who reported having diarrhea is comparable to estimates in previously published reviews[5]; however, the high proportion who reported repeated diarrheal episodes over the short duration of the exercise is notable. Additionally, these data enable power calculations for planned interventional trials assessing diarrhea prevention tools in these settings. These data also suggest that the development of the training site and control of the environment and training population may have reduced the proportion reporting TD in this cycling population since 1999–2000 when the proportion with diarrhea was estimated at 40–60% (UK Ministry of Defence, unpublished internal report, February 2001).

Risk factors similar to those in prior studies were identified[11,13–15]; however, by far the greatest risk factor was having a colleague with TD. This may represent a common point-source exposure or person-to-person spread. Based on the typical etiology of TD, and the transmission of common pathogens, the former is more likely than the latter.

Participants were unlikely to seek treatment for TD, consistent with other studies on care-seeking behavior in cases of TD.[16] This may be due to the illness being less severe, perception of a lack of viable treatment strategies, and/or social constraints resulting in decreased reporting. Self-treatment was relatively rare; however, 8.9% of participants with diarrhea used the antimotility agent, loperamide. Recent studies have shown that treatment regimens that include an antimotility agent and an appropriate antibiotic can produce rapid clinical resolution and minimize lost duty time.[17]

There are several limitations that should be considered when interpreting the results of this study. First, the reliance on self-reported data may have introduced response bias. It is possible that those who had at least 1 diarrheal episode may have been more likely to complete the questionnaire than those who did not. It is also possible that questionnaire respondents misclassified their exposure to potential risk factors, the outcome of diarrhea, and/or the characteristics of their illnesses. In addition, participants may have mischaracterized concomitant symptoms that may not have occurred concurrent with their diarrheal illnesses. Prior studies have also highlighted underreporting of TD in deployment settings.[18] Moreover, data on the background characteristics of soldiers who were eligible to complete the survey but who did not do so would have helped to assess the generalizability of the results to the larger training population. Finally, efforts to validate the survey or to assess its internal validity and reliability were limited, which may have affected the results.

Ongoing data collection is needed to assess the continued disease risk associated with TD and other potential infectious disease

TABLE 2. Summary of diarrheal illness characteristics among active duty British military personnel participating in the British Army training unit 6-week exercise Askari Storm, Nanyuki, Kenya, January–June 2014

	No. of respondents who reported TD (n=269)	%
No. of diarrheal episodes		
1	119	44.2
2	74	27.5
≥3	73	27.1
Missing	3	1.1
Duration (days)[a]		
1	51	19.0
2–3	120	44.6
4–5	44	16.4
>5	49	18.2
Missing	5	1.9
No. of stools per day[a]		
<3	68	25.3
3–5	135	50.2
6–10	50	18.6
>10	9	3.4
Continuous	5	1.9
Missing	2	0.7
Symptoms[b]		
Fever	36	13.4
Abdominal pain/ cramps	172	63.9
Nausea or vomiting	51	19.0
Joint pain	15	5.6
Muscle aches	6	2.2
Blood in diarrhea	15	5.6
Diarrhea management[b]		
Reported sick to physician or medic	67	24.9
Bedded down with diarrhea	53	19.7
Self-treated diarrhea	126	46.8
Self-treated with water	22	8.2
Self-treated with Imodium	24	8.9
Self-treated with oral rehydration therapy	26	9.7

No., number; TD, travelers' diarrhea.
[a]Occurring during the most severe illness.
[b]Multiple responses to this survey item were allowed.

TABLE 3. Crude and adjusted odds ratios of diarrhea among active duty British military personnel participating in the British Army training unit 6-week exercise Askari Storm, Nanyuki, Kenya, January–June 2014

Variable	No.	Crude OR	95% CI	AOR[a]	95% CI
Smoker	488	0.91	0.69–1.20	--	--
On regular medication	72	1.25	0.72–2.14	--	--
On antimalarial medication	739	1.00	0.60–1.64	--	--
Appendectomy	64	2.29	1.36–3.86	--	--
Drank uncertified water	133	1.60	1.07–2.38	--	--
Current/previous chronic bowel problems	20	1.82	0.72–4.62	--	--
Ate locally sourced/produced food within 2 days before diarrhea onset	269	3.47	2.58–4.68	2.00	1.08–3.72
Swam/bathed/patrolled through local water within 3 days before getting diarrhea	304	2.72	2.03–3.63	1.67	0.091–3.07
Colleague with diarrhea	147	63.75	36.51–111.33	51.78	29.44–91.06

No., number; OR, odds ratio; CI, confidence interval; AOR, adjusted odds ratio.
[a]AORs were calculated from a logistic regression model that included all potential risk factors.

threats of concern. Additionally, efforts to understand the pathogens causing disease in this population are needed to ensure appropriately targeted interventions and treatments. Utilization of recently established clinical practice guidelines for TD treatment, while not preventing TD, may minimize the impact of the illness on personnel.[19]

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Disclosure: This study was exempt from the Ministry of Defence Research and Ethics Committee approval (MOD JSP 536 dated 21 January 2011) and was conducted under support of the Military Infectious Disease Research Program.

Conflict of interest: The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Surveillance Snapshot: Norovirus Outbreaks in Military Forces, 2015–2019

Leslie L. Clark, PhD, MS

TABLE. Reported NoV outbreaks in military forces, 2015–2019

Month and year of outbreak onset	Setting	Estimated attack rate (%) [no. of NoV cases out of total personnel]	Description	Ref. no.
April 2015	Army base, Portugal	4.9% [46 cases out of 938]	7 specimens positive for NoV GI.9	7
August 2015	Military camp, Singapore	3.0% [150 out of 5,000]	New emerging strains of caliciviruses [sapovirus (GII.3) and NoV(GI.7 and GII.17)] identified as causative agents	8
October 2015	Army base, Portugal	40.0% [36 cases out of 90]	1 specimen tested positive for NoV GII.17; 22 cases hospitalized	9
January 2016	Army base, Azores (Portugal)	40.0% [20 cases out of 50]	5 specimens positive for NoV GII.Pe-GII.4 Sydney; likely spread by food worker	9
January 2016	Deployed French armed forces, Central African Republic	22.2% [200 cases out of 900]	6 specimens positive for NoV GII; foodborne outbreak likely due to local food handlers	10
February 2016	Military unit, France	34.3% [103 cases out of 300]	1 specimen positive for NoV GII.17; likely spread by food worker	11
November 2016	Army base, Portugal	7.4% [29 cases out of 394]	11 specimens positive for NoV GII.P2-GII.2	9
January 2017	Army military exercise, Portugal	20.0% [17 cases out of 84]	3 specimens positive for NoV GII.P16-GII.2	9
December 2017	Multiple Army units, Lisbon, Portugal	3.5% [31 out of 874 in 3 Army units]	11 samples positive for NoV GII.P16-GII.4 Sydney	12
May 2018	U.S. military, Camp Arifjan, Kuwait	No attack rate reported; 91 cases (8 confirmed, 83 suspected)	8 specimens positive via BioFire FilmArray; genotype unspecified	13

NoV, norovirus; no., number; Ref., reference.

Norovirus (NoV) infections are a leading cause of acute gastroenteritis outbreaks in both the U.S. and worldwide.[1] Although most cases of NoV illness are mild and self-resolving, NoV outbreaks can cause significant morbidity in military personnel and have a significant operational impact on affected units.[2,3]

NoV outbreaks are difficult to prevent because of several characteristics. NoVs are highly contagious and transmitted through multiple routes, including person-to-person direct contact and exposure to contaminated food, water, aerosols, and fomites. NoVs have demonstrated long-term stability in the environment and resistance to temperature extremes and standard disinfection methods. Human infections with NoV are associated with a prolonged shedding period that promotes secondary transmission. Finally, previous NoV infection often does not confer lasting immunity to reinfection with the same NoV strain or to different strains.[4]

Previously, the *MSMR* has summarized published reports of NoV outbreaks in military forces.[5,6] This update captures NoV outbreak reports in military forces published in the 5-year period between 2015 and 2019 (**Table**).[7–13] The surveillance period included the years 2015 and 2016 (covered in a previous report) in order to identify NoV outbreak reports published since the last *MSMR* summary. Attack rates are provided when explicitly stated or when they could be derived from the data provided in published reports. This summary includes only outbreaks in military settings where the authors explicitly reported NoVs as a primary cause of the outbreak.

Several of the published reports documented significant operational impacts due to the NoV outbreak. Notably, the Camp Arifjan outbreak (and the public health response to contain it) resulted in the shutdown of a key personnel transit station in the U.S. Central Command for approximately 10 days,[13] while the 2016 outbreak among French military personnel resulted in the cancellation of a field exercise because of a lack of personnel able to participate.[11]

The number of military-associated NoV outbreaks reported in peer-reviewed literature likely represents only a small fraction of all NoV outbreaks in military populations. During the surveillance period in this update, several large, military-associated NoV outbreaks were also reported in the press. Notable examples include a 2017 NoV outbreak originating in base child care centers at Hurlburt Field (the headquarters of the Air Force's 1st Special Operation Wing) that resulted in more than 100 cases[14] and a 2019 outbreak at the U.S. Air Force Academy that affected about 400 cadets.[15] Military enteric disease surveillance programs also routinely identify NoV outbreaks that are not published in the peer-reviewed literature. For example, between 2011 and 2016, the Naval Health Research Center's Operational Infectious Disease Directorate identified 18 NoV GI- and 26 NoV GII-associated outbreaks in U.S. military recruits.[16] This finding highlights the importance of enteric disease surveillance programs in accurately quantifying the burden of NoV outbreaks in military populations.

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Update: Incidence of Acute Gastrointestinal Infections and Diarrhea, Active Component, U.S. Armed Forces, 2010–2019

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Laboratory, reportable medical event, and medical encounter data were analyzed to identify incident cases of acute gastrointestinal (GI) infections caused by *Campylobacter*, nontyphoidal *Salmonella*, *Shigella*, *Escherichia coli* (*E. coli*), or norovirus as well as cases of unspecified gastroenteritis/diarrhea among U.S. active component service members during 2010–2019. Unspecified gastroenteritis/diarrhea diagnoses accounted for 98.8% of identified incident cases (4,135.1 cases per 100,000 person-years [p-yrs]). *Campylobacter* was the most frequently identified specific etiology (17.6 cases per 100,000 p-yrs), followed by nontyphoidal *Salmonella* (12.7 cases per 100,000 p-yrs), norovirus (10.8 cases per 100,000 p-yrs), *E. coli* (7.5 cases per 100,000 p-yrs) and *Shigella* (3.2 cases per 100,000 p-yrs). Crude annual rates of norovirus, *E. coli*, *Campylobacter*, and *Salmonella* infections and unspecified gastroenteritis/diarrhea increased between 2010 and 2019 while rates of *Shigella* infections were relatively stable. Among deployed service members during the 10-year period, only 150 cases of the 5 specific causes of gastroenteritis were identified but a total of 20,377 cases of unspecified gastroenteritis/diarrhea were diagnosed (3,062.9 per 100,000 deployed p-yrs).

WHAT ARE THE NEW FINDINGS?

The crude overall incidence rate of unspecified gastroenteritis/diarrhea among active component service members during 2010–2019 was more than 75 times the combined overall rates of acute GI infections attributable to the 5 specific pathogens of interest. Annual rates of unspecified gastroenteritis/diarrhea and all pathogen-specific GI infections except *Shigella* increased over the course of the 10-year period.

WHAT IS THE IMPACT ON READINESS AND FORCE HEALTH PROTECTION?

Unspecified gastroenteritis and diarrheal illnesses remain prevalent among military personnel and can significantly degrade service members' readiness for duty. Increased diagnostic testing of nonspecific acute GI infections is warranted to further elucidate which GI pathogens are the most prevalent in this population.

Acute gastrointestinal (GI) infections and diarrheal disease have been the perennial cause of significant morbidity in military personnel in both deployed and nondeployed settings.[1,2] In American military personnel, acute diarrheal illness was the most commonly reported noncombat disease among deployed personnel during Operation Iraqi Freedom and Operation Enduring Freedom.[3] More recent analyses of the burden of diarrheal disease among active component U.S. service members estimated that diarrheal diseases accounted for 42,601 healthcare encounters affecting 36,387 service members in 2019.[4]

Acute GI infections can be caused by many bacterial, viral, or parasitic pathogens; however, studies in military populations have often focused on *Campylobacter* spp., nontyphoidal *Salmonella* spp., *Shigella* spp., norovirus, or *Escherichia coli* as pathogens responsible for a majority of GI infections.[5–7] In 2017, the *Medical Surveillance Monthly Report* (*MSMR*) published estimated incidence rates of diagnoses of *Campylobacter,* nontyphoidal *Salmonella*, *Shigella*, norovirus, and *E. coli* infections among active component service members during 2007–2016.[8–11] The current report updates and expands upon these previous analyses by estimating incidence rates of diagnoses of GI infections attributed to the aforementioned 5 pathogens as well as diagnoses of unspecified gastroenteritis/diarrhea among active component service members between 2010 and 2019.

METHODS

The surveillance period was 1 January 2010 through 31 December 2019. The surveillance population consisted of all active component service members of the U.S. Armed Forces who served in the Army, Navy, Air Force, or Marine Corps at any time during the 10-year surveillance period.

Diagnoses of pathogen-specific acute GI infections (*Campylobacter,* nontyphoidal *Salmonella*, *Shigella*, norovirus, or *E. coli*) and unspecified gastroenteritis/diarrhea were ascertained from records of reports of notifiable medical events and from administrative records of all medical encounters of individuals who received care in fixed (i.e., not deployed or at sea) medical facilities of the Military Health System (MHS) or civilian facilities in the purchased care system. All such records are maintained in the Defense Medical Surveillance System. In addition, acute GI infection cases were ascertained from Navy and Marine Corps Public Health Center records of laboratory identification of GI pathogens in stool or rectal samples tested in laboratories of the MHS.

For surveillance purposes, an incident case of acute GI infection was defined as any one of the following: 1) a laboratory-confirmed identification of GI infection in a stool or rectal sample, 2) a reportable medical event record of "confirmed" GI infection, 3) a single hospitalization with any of the defining diagnoses for acute GI infections in any diagnostic position, or 4) a single outpatient encounter with any of the defining diagnoses for GI infections in any diagnostic position **(Table 1)**. An incident case of unspecified gastroenteritis/diarrhea was defined as 1 hospitalization or outpatient medical encounter with any of the case defining diagnoses of diarrhea in any diagnostic position **(Table 1)**.

An individual could be considered a case once every 180 days for each of the 5 types of acute GI infections and unspecified gastroenteritis/diarrhea. The incidence date was considered the date of the earliest rectal or fecal sample that was confirmed positive for each acute GI infection, the date documented in a reportable medical event report for each acute GI infection, or the date of the first hospitalization or outpatient medical encounter that included the defining diagnosis of a case of acute GI infection/diarrhea. Incidence rates were calculated as the number of cases per 100,000 person-years (p-yrs).

Cases of acute GI infections and unspecified gastroenteritis/diarrhea occurring during deployments were analyzed separately. These cases were identified from the medical records of deployed service members whose healthcare encounters were documented in the Theater Medical Data Store (TMDS). An incident case during deployment was based on a single medical encounter with a diagnosis recorded in the TMDS that occurred between the start and end dates of a service member's deployment record.

TABLE 1. ICD-9 and ICD-10 diagnostic codes used to identify cases of GI infection and unspecified gastroenteritis/diarrhea

Type of GI infection	ICD-9[a]	ICD-10[a]
Campylobacter enteritis	008.43	A04.5
Nontyphoidal *Salmonella* enteritis	003.0	A02.0
Shigella enteritis	004.*	A03.*
Escherichia coli enteritis	008.0*	A04.0, A04.1, A04.2, A04.3, A04.4
Norovirus enteritis	008.63	A08.11
Unspecified gastroenteritis/diarrhea	009, 009.0, 009.1, 009.2, 009.3, 787.91	A09, R19.7

[a]An asterisk (*) indicates that any subsequent digit/character is included.
ICD, International Classification of Diseases; GI, gastrointestinal.

RESULTS

During 2010–2019, there were 2,241 diagnosed cases of *Campylobacter* infections, 1,616 of *Salmonella* infections, 406 of *Shigella* infections, 952 of *E. coli* infections, 1,379 of norovirus infections, and 527,357 diagnosed cases of unspecified gastroenteritis among active component service members **(Table 2)**. The crude overall incidence rates per 100,000 p-yrs were 17.6 for *Campylobacter* infections, 12.7 for *Salmonella* infections, 3.2 for *Shigella* infections, 7.5 for *E. coli* infections and 10.8 for norovirus infections. The crude overall incidence rate of unspecified gastroenteritis/diarrhea (4,135.1 per 100,000 p-yrs) was more than 75 times the combined overall rates of acute GI infections attributable to the 5 specific pathogens of interest.

Examination of overall incidence rates by demographic characteristics showed that, compared with males, females had higher rates of all 5 types of acute GI infections and unspecified gastroenteritis/diarrhea **(Table 2)**. Active component service members aged 45 years or older had the highest overall rates of *Campylobacter* and *E. coli* infections. Compared with those in older age groups, younger service members had the highest rates of norovirus infection and unspecified gastroenteritis/diarrhea. For *Shigella* infections, service members between 35 and 39 years old had the highest overall incidence rate. Relative to those in other race/ethnicity groups, non-Hispanic black service members had lower rates of *Campylobacter*, *Salmonella*, and norovirus infections but the highest rates of *Shigella* infections and unspecified gastroenteritis/diarrhea **(Table 2)**. Across the services, members of the Army and Air Force had higher rates of all 5 types of acute GI infections and unspecified gastroenteritis/diarrhea compared with members of the other services. Marine Corps members had the lowest overall rates of *Campylobacter*, *Shigella*, and norovirus infections as well as the lowest rate of unspecified gastroenteritis/diarrhea. With the exception of *Campylobacter* and *Shigella* infections, recruits had higher overall incidence rates compared with nonrecruits. Service members in healthcare occupations had the highest overall rates of all types of GI infections, except for norovirus, compared with those working in other military occupations.

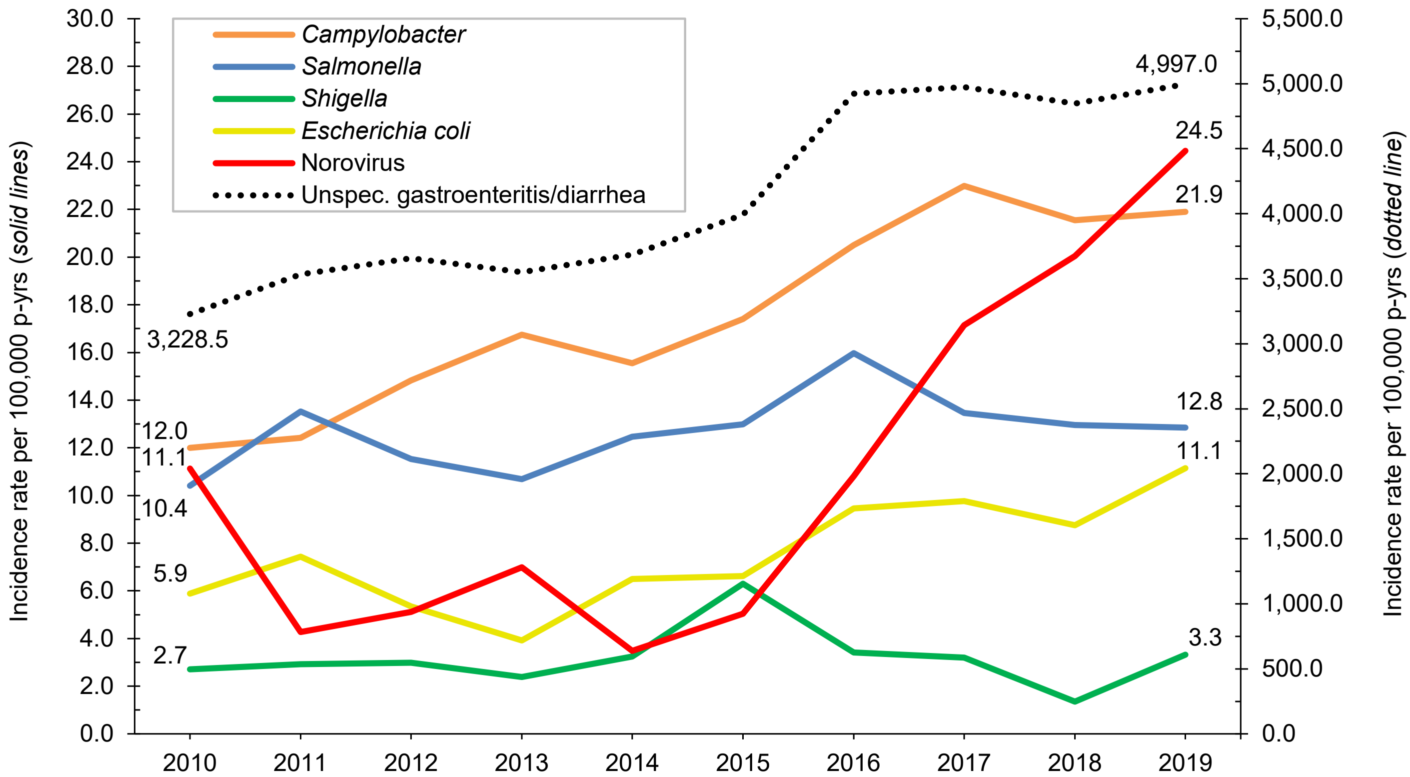
Over the course of the 10-year surveillance period, crude annual incidence rates of *E. coli* infections and unspecified gastroenteritis/diarrhea increased by 89.6% and 54.8%, respectively. Crude annual rates of *Campylobacter* infections increased from 2010 through 2017 (82.6%) and then were relatively stable for the remainder of the surveillance period. Crude annual rates of norovirus infections

TABLE 2. Incident cases and incidence rates of GI infections by type of infection, active component, U.S. Armed Forces, 2010–2019

	Campylobacter		*Salmonella*		*Shigella*		*Escherichia coli*		Norovirus		Unspecified gastro-enteritis/diarrhea	
	No.	Rate[a]	No.	Rate[a]	No.	Rate[a]	No.	Rate[a]	No.	Rate[a]	No.	Rate[a]
Total	2,241	17.6	1,616	12.7	406	3.2	952	7.5	1,379	10.8	527,357	4,135.1
Sex												
Male	1,860	17.3	1,345	12.5	308	2.9	796	7.4	1,135	10.5	395,152	3,672.3
Female	381	19.1	271	13.6	98	4.9	156	7.8	244	12.2	132,205	6,634.4
Age group (years)												
<20	55	6.3	95	10.8	7	0.8	44	5.0	143	16.3	39,381	4,495.7
20–24	576	14.3	539	13.3	85	2.1	210	5.2	532	13.2	193,631	4,794.3
25–29	627	20.7	407	13.4	98	3.2	232	7.7	324	10.7	134,556	4,446.4
30–34	380	18.8	258	12.8	96	4.8	190	9.4	200	9.9	75,546	3,738.3
35–39	269	18.4	168	11.5	80	5.5	128	8.8	103	7.1	47,063	3,224.2
40–44	190	22.5	98	11.6	27	3.2	77	9.1	47	5.6	24,314	2,880.9
45–49	97	27.3	33	9.3	9	2.5	45	12.7	22	6.2	9,429	2,652.6
50+	47	35.6	18	13.6	4	3.0	26	19.7	8	6.1	3,437	2,600.4
Race/ethnicity group												
Non-Hispanic white	1,393	18.6	1,081	14.4	212	2.8	590	7.9	845	11.3	301,442	4,023.4
Non-Hispanic black	258	12.5	191	9.3	91	4.4	144	7.0	185	9.0	102,504	4,984.1
Hispanic	327	18.4	194	10.9	69	3.9	124	7.0	206	11.6	73,868	4,147.2
Other/unknown	263	18.5	150	10.5	34	2.4	94	6.6	143	10.0	49,543	3,481.3
Service												
Army	910	19.4	651	13.9	188	4.0	464	9.9	601	12.8	239,958	5,108.5
Navy	471	14.8	278	8.8	79	2.5	151	4.8	271	8.5	95,003	2,992.8
Air Force	735	24.0	454	14.8	115	3.8	240	7.8	365	11.9	142,109	4,634.0
Marine Corps	125	6.9	233	12.8	24	1.3	97	5.3	142	7.8	50,287	2,770.8
Rank/grade												
Junior enlisted (E00–E04)	719	12.9	702	12.6	110	2.0	326	5.9	756	13.6	286,532	5,153.6
Senior enlisted (E05–E09)	964	19.4	593	11.9	194	3.9	401	8.1	482	9.7	185,870	3,733.0
Junior officer (O01–O04)	402	24.4	254	15.4	78	4.7	156	9.5	116	7.0	42,895	2,603.0
Senior officer (O05–O10)	119	30.5	42	10.8	13	3.3	53	13.6	16	4.1	7,451	1,910.9
Warrant officer (W01–W05)	37	21.0	25	14.2	11	6.2	16	9.1	9	5.1	4,609	2,613.5
Status												
Recruit	14	4.4	53	16.6	1	0.3	32	10.0	107	33.6	13,659	4,287.3
Non-Recruit	2,227	17.9	1,563	12.6	405	3.3	920	7.4	1,272	10.2	513,698	4,131.2
Military occupation												
Combat-specific[b]	241	13.6	217	12.2	40	2.3	130	7.3	167	9.4	50,959	2,867.5
Motor transport	38	10.2	45	12.1	2	0.5	20	5.4	52	14.0	17,395	4,671.3
Pilot/air crew	115	24.6	69	14.8	19	4.1	33	7.1	28	6.0	10,594	2,266.5
Repair/engineering	548	14.6	418	11.1	97	2.6	233	6.2	323	8.6	146,280	3,898.1
Communications/intelligence	549	19.9	368	13.3	101	3.7	207	7.5	289	10.5	131,643	4,762.3
Healthcare	319	28.0	172	15.1	76	6.7	107	9.4	147	12.9	63,253	5,554.2
Other/unknown	431	17.4	327	13.2	71	2.9	222	8.9	373	15.0	107,233	4,323.0

[a]Incidence rate per 100,000 person-years.
[b]Infantry/artillery/armor/combat engineering.
GI, gastrointestinal.

FIGURE 1. Crude annual incidence rates of GI infections, by type of infection, active component, U.S. Armed Forces, 2010–2019



GI, gastrointestinal; Unspec., unspecified.

decreased from 11.1 per 100,000 p-yrs in 2010 to a low of 3.5 per 100,000 p-yrs in 2014, after which rates increased steadily to a peak of 24.5 per 100,000 p-yrs in 2019. Annual rates of *Salmonella* infections fluctuated between a low of 10.4 per 100,000 p-yrs in 2010 and a high of 16.0 per 100,000 p-yrs in 2016. Annual rates of *Shigella* infections were relatively stable during the 10-year period and, with the exception of 2015, were consistently lower than the rates of the other types of GI infections **(Figure 1)**.

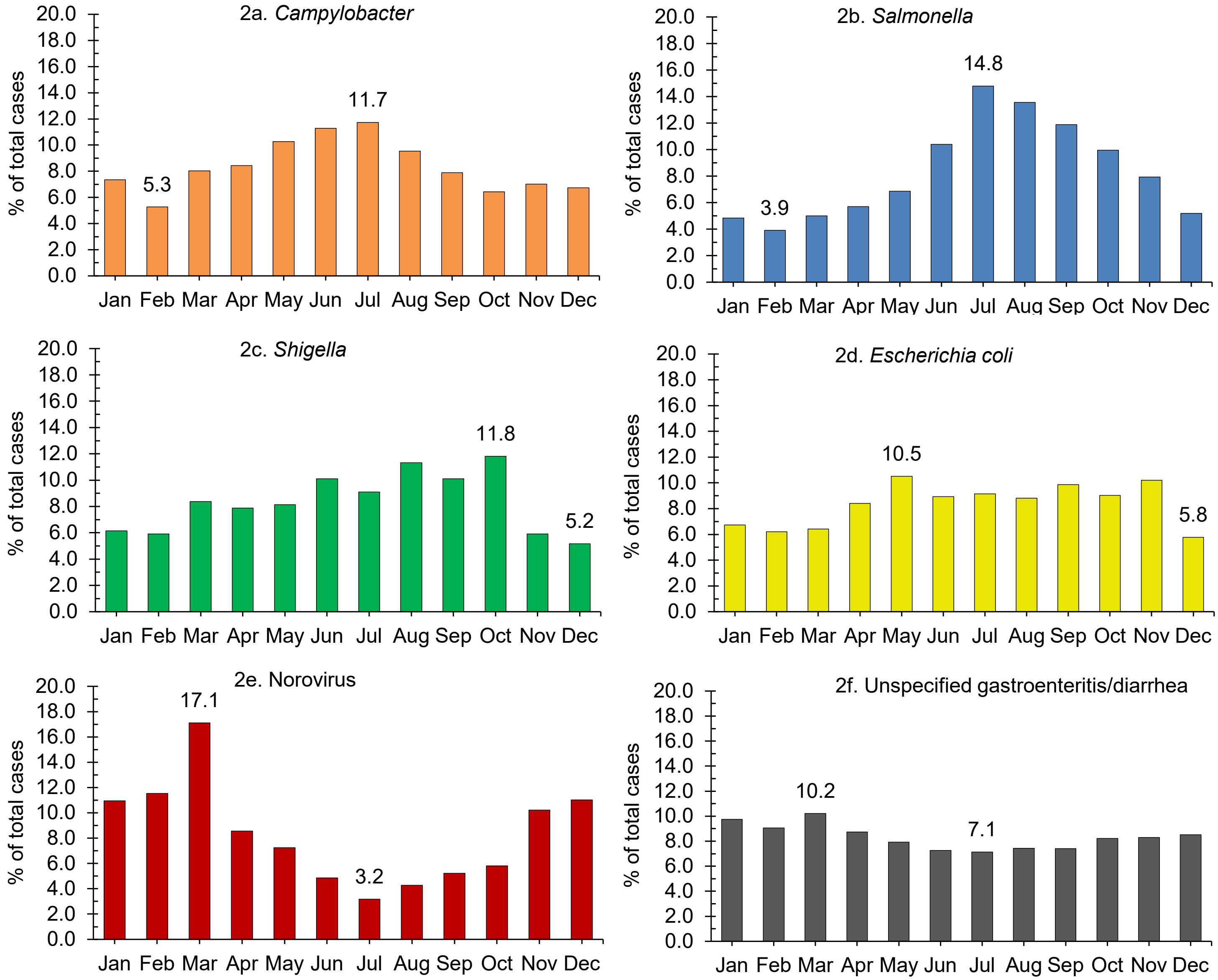
Between 2010 and 2019, the highest percentages of cases of infection by the bacterial pathogens of interest tended to be diagnosed and/or reported during the warmer months in the Northern Hemisphere **(Figures 2a–2d)**. The most pronounced seasonal patterns were seen for cases of *Campylobacter* and *Salmonella* infections; the highest percentages of total *Campylobacter* cases were diagnosed from May through August **(Figure 2a)** and the majority of total *Salmonella* infection cases were diagnosed between June and October (60.6%) **(Figure 2b)**. Unlike cases of infection by these bacterial pathogens, the majority of total norovirus infection cases were diagnosed during November–March (60.8%), with the highest percentage of total cases in March **(Figure 2e)**. The highest percentage of unspecified gastroenteritis/diarrhea cases was diagnosed in March (10.2%); however, the distribution of monthly percentages for unspecified gastroenteritis/diarrhea showed the least variation compared to those of the other 5 types of GI infection **(Figure 2f)**.

During the 10-year surveillance period, there were 11 diagnosed cases of *Campylobacter* infections, 56 of *Salmonella* infections, 11 of *Shigella* infections, 43 of *E. coli* infections, and 29 of norovirus infections among deployed active component service members **(data not shown)**. The paucity of cases precluded any attempts to identify demographic patterns of infection during deployment. A total of 20,377 cases of unspecified gastroenteritis/diarrhea were diagnosed during the surveillance period among deployed active component service members for a crude overall incidence rate of 3,062.9 per 100,000 deployed p-yrs. Compared to their respective counterparts, females, those aged 50 years or older, non-Hispanic blacks, Air Force members, and commissioned officers had higher overall rates of unspecified gastroenteritis/diarrhea. Deployed active component service members in other/unknown military occupations, communications/intelligence, and healthcare had higher overall rates of unspecified gastroenteritis/diarrhea compared to those working in other occupations **(Table 3)**.

EDITORIAL COMMENT

In the current analysis, the vast majority (98.8%) of cases identified during 2010–2019 represented diagnoses of

FIGURE 2. Cumulative percentage distributions of diagnoses and reported cases of GI infections and unspecified gastroenteritis/diarrhea, by type of infection and month of clinical presentation or diagnosis, active component, U.S. Armed Forces, 2010–2019



unspecified gastroenteritis/diarrhea. The crude overall incidence rate of unspecified gastroenteritis/diarrhea was considerably higher than the combined overall rates of GI infections attributable to the 5 pathogens of interest. For acute GI infections with identified etiologies, the highest incidence rates were for *Campylobacter* infections, followed by *Salmonella*, *E. coli*, and *Shigella*. Crude annual incidence rates of all pathogen-specific acute GI infections except *Shigella* increased over the course of the 10-year surveillance period. Rates of norovirus infections rose by the highest percentage overall (119.9%), with the greatest slope of increase occurring between 2014 and 2019. Crude annual rates of unspecified gastroenteritis/diarrhea also increased during this period while rates of *Shigella* infections were relatively stable.

Comparatively few diagnoses of the pathogen-specific acute GI infections of interest were ascertained from TMDS records of deployed service members' healthcare encounters during the 10-year study period. While acute diarrheal illness is common in the deployed setting, many cases will not undergo laboratory testing. This can be due to the self-limited nature of the condition, potentially rapid resolution of cases as a result of effective treatment, or limited laboratory capabilities in theater.[12]

It is important to note that the incidence rates reported here likely underestimate the true burden of acute GI infections and diarrheal disease in this population. To be counted as a case in this analysis, military personnel had to seek medical care and receive a diagnosis of acute GI infection or diarrhea, have

TABLE 3. Number of incident cases and incidence rates of unspecified gastroenteritis/diarrhea, active component service members during deployment, 2010–2019

Characteristic	Unspecified gastroenteritis/diarrhea	
	No.	Rate[a]
Total	20,377	3,062.9
Sex		
Male	16,390	2,748.1
Female	3,987	5,788.6
Age group (years)		
<20	381	2,331.2
20–24	6,454	2,816.2
25–29	5,637	3,131.6
30–34	3,461	3,247.1
35–39	2,391	3,264.9
40–44	1,377	3,387.8
45–49	519	3,490.0
50+	157	3,550.1
Race/ethnicity group		
Non-Hispanic white	13,019	3,062.8
Non-Hispanic black	3,409	3,357.9
Hispanic	2,396	2,924.9
Other/unknown	1,553	2,735.1
Service		
Army	11,328	3,006.5
Navy	683	1,585.1
Air Force	7,541	4,949.0
Marine Corps	825	886.7
Rank/grade		
Junior enlisted (E00–E04)	8,579	2,967.4
Senior enlisted (E05–E09)	7,463	2,903.0
Junior officer (O01–O04)	3,342	3,725.5
Senior officer (O05–O10)	616	3,743.8
Warrant officer (W01–W05)	377	2,914.2
Military occupation		
Combat-specific[b]	2,854	1,782.0
Motor transport	648	3,065.2
Pilot/air crew	1,016	3,091.9
Repair/engineering	5,213	3,106.9
Communications/intelligence	5,455	3,635.5
Healthcare	1,444	3,613.1
Other/unknown	3,747	4,014.9

[a]Incidence rate per 100,000 person-years.
[b]Infantry/artillery/armor/combat engineering.

a positive laboratory result for 1 of the specified GI pathogens, or be reported as a case in the reportable medical event system. However, many individuals with GI illnesses do not seek medical care for their illnesses. In a recent systematic review of traveler's diarrhea (TD), incidence rates of TD were higher in studies that relied on self-report rather than on clinical diagnosis or reportable medical events.[5] The same review reported that only 38% of individuals reporting diarrheal illnesses sought medical care.[5] Another limitation of the current analysis is that many acute GI infections were not attributed to particular pathogens because of the lack of testing to determine specific etiologies. Finally, the laboratory data used in this analysis did not include laboratory tests conducted in the civilian purchased care system, so positive tests in that system are not reflected in this report.

Despite the likely underascertainment of total cases of pathogen-specific acute GI infection, the counts and rates of the types of infections reported here represent findings consistent with earlier *MSMR* analyses[8–11] and the known epidemiology of these pathogens.[13] Since no pattern of seasonality was observed for unspecified gastroenteritis/diarrhea, it is unclear whether these cases were predominantly caused by viral or bacterial pathogens. Given that unspecified gastroenteritis and diarrheal illnesses remain prevalent among military personnel and can significantly degrade service members' readiness for duty, increased diagnostic testing of nonspecific acute GI infections is warranted to further elucidate which GI pathogens are the most prevalent in this population.

Acknowledgments: The authors thank the Navy and Marine Corps Public Health Center, Portsmouth, VA, for providing laboratory data for this analysis.

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Clean.

Wash hands, utensils, and cutting boards before and after contact with raw meat, poultry, seafood, and eggs.

Separate.

Keep raw meat and poultry apart from foods that won't be cooked.

Cook.

Use a food thermometer – you can't tell food is cooked safely by how it looks.

Chill.

Chill leftovers and takeout foods within 2 hours and keep the fridge at 40 °F or below.

from USDA and the Partnership for Food Safety Education

Medical Surveillance Monthly Report (MSMR)
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ISSN 2158-0111 (print)
ISSN 2152-8217 (online)