Pneumonia at Marine Corps Recruit Depots: Current Trends in Ambulatory Encounters and Inpatient Discharges

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ABSTRACT Background: Acute respiratory infections are recognized as a significant source of morbidity for military populations, particularly for recruits. This analysis aims to describe the pneumonia burden at Marine Corps Recruit Depots (MCRD) in Parris Island and San Diego during 2007–2014, as these two depots maintain noteworthy comparisons in vaccine and prophylaxis policies. First, both depots reinstated the adenovirus vaccine in October 2011. Second, San Diego provides the pneumococcal polysaccharide vaccine to all recruits within the first 2 days of arrival, although Parris Island does not routinely vaccinate for *Streptococcus pneumoniae*. Third, recruits at San Diego routinely receive three doses of penicillin G benzathine for group A *Streptococcus* bacterium prophylaxis, although those at Parris Island receive one dose year-round and a second dose during the winter months when group A *Streptococcus* bacterium burden is expected to increase. Methods: Monthly pneumonia rates were estimated using diagnostic codes from ambulatory encounters and inpatient discharge records, and specific causative organisms were assessed using code extenders within the International Classification of Diseases, Ninth Revision. Regression analyses and Spearman's correlation rank tests were used to describe significant trends and the relationship between ambulatory and inpatient rates at each depot. Findings: Although our results indicate the majority of ambulatory encounters and inpatient discharges are attributed to unspecified pneumonia diagnostic codes at both locations, these data still lend noteworthy trends. At both locations, linear trends in ambulatory pneumonia rates significantly declined over the 8-year period, whereas inpatient rates demonstrated less variability and did not significantly decline. Both depots experienced prolonged, heightened pneumonia trends from early 2009–2010, a period which included the global influenza pandemic. Following reimplementation of the adenovirus vaccine during October 2011, the average ambulatory rates at MCRD San Diego (38.02 per 1,000 recruit-months vs. 65.59 per 1,000 recruit-months) and MCRD Parris Island (10.9 per 1,000 recruit-months vs. 22.8 per 1,000 recruit-months) were approximately half the average rate before utilization of the adenovirus vaccine. At MCRD San Diego, a weak correlation between monthly inpatient and ambulatory pneumonia rates suggests that trends for potentially severe pneumonia do not follow those for generalized disease ($r^S = 0.43$; $p < 0.05$), whereas correlation results at MCRD Parris Island indicate these monthly trends are positively associated ($r^S = 0.71$; $p < 0.05$). Discussion: These observations underscore the evidence that pneumonia burden among military recruits is not associated with one single etiology. Recruits are at risk for a range of etiologic agents, and control measures should include a combination of specific medical countermeasures that focus on a single bacterial or viral disease as well as nonmedical public health measures that reduce the overall burden of circulating infectious respiratory agents. The trends described in this report, coupled with the similarities and dissimilarities for public health prevention practices at each depot, may warrant further investigation for a systematic review of social and environmental factors within recruit populations at these two locations.

BACKGROUND

Acute respiratory infections are recognized as a significant source of morbidity for military populations.[1] Respiratory disease has been responsible for an estimated 25 to 30% of infectious disease-related hospitalizations among active duty personnel, with pneumonia cited as a leading medical cause of lost workdays.[2] Evidence points to a larger risk for respiratory illness in military recruits, potentially as a result of crowded living quarters, limited time for personal hygiene, and persistence of circulating disease within the environment.[3–6]

Historically, adenovirus has been recognized as an important respiratory illness affecting military recruit populations.[7–12] In 1971, the Department of Defense began to administer adenovirus types 4 and 7 vaccines to control respiratory illness in recruit training centers. When vaccine production ceased in 1996, the burden of adenovirus infection among the U.S. recruit population returned to high levels experienced before routine administration.[7] Following reinstatement of the vaccine among the trainee population in October 2011, rates of febrile respiratory illness in basic military training facilities declined significantly.[8]

Bacterial pathogens have also been cited in literature as causative agents for respiratory disease in military populations, including *Streptococcus pneumoniae* and *S. pyogenes*, known as group A *Streptococcus* bacterium (GAS).[1] Routine administration of penicillin for prophylaxis of basic trainees against group A streptococcal infection has been shown to be effective in some populations with historically high incidence of disease. The Navy Bureau of Medicine and Surgery instruction 6220.8 directs

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year-round antibiotic prophylaxis of all recruits upon arrival to boot camp for the prevention and control of GAS. Additional prophylaxis beyond the fourth week of training is to be guided by local disease surveillance.[13] In addition, the Navy Bureau of Medicine and Surgery instruction 6230.15B notes that the pneumococcal vaccine is not routinely administered but may be directed on the basis of *S. pneumoniae* disease incidence and severity.[14]

Although the risk for respiratory disease exists across the Department of Defense recruit training centers, this evaluation specifically describes the pneumonia burden in Marine Corps Recruit Depots (MCRD). At these two locations, potential differences in pneumonia preventive and hygienic measures may be anecdotally described but not quantified against current trends; however, these two depots have noteworthy comparisons for vaccine and prophylaxis policies. First, both depots reinstated the adenovirus vaccine in October 2011. Second, San Diego provides the pneumococcal polysaccharide vaccine (PPSV23) to all recruits within the first 2 days of arrival, although Parris Island does not routinely vaccinate for *S. pneumoniae*. Third, recruits at San Diego routinely receive three doses of penicillin G benzathine (Bicillin) for GAS prophylaxis, although those at Parris Island receive one dose year-round and a second dose during the winter months when GAS burden is expected to increase. At both locations, alternate prophylaxis regimens to Bicillin are provided for recruits with a penicillin allergy and to others requiring different regimens. These may include oral azithromycin (1 g weekly for 4 weeks), oral penicillin-VK (250 mg twice daily for 4 weeks), or oral erythromycin (250 mg twice daily for 4 weeks).

This analysis aims to describe the current pneumonia trends at the MCRDs in San Diego and Parris Island using electronic inpatient discharge and ambulatory medical encounter data in relation to vaccination and prophylaxis policies.

METHODS

Marine Corps recruits must complete 12 weeks of basic training at one of two locations. Recruits who reside west of the Mississippi River are assigned to the MCRD in San Diego, while those who reside east are assigned to the MCRD at Parris Island, South Carolina. All female recruits, regardless of residence, train at MCRD Parris Island.

The recruit population at both locations was identified through personnel records from the Defense Manpower Data Center database for calendar years 2007–2014. Monthly rosters of trainees at each location were created using unit identification codes. The rosters were matched to medical encounter databases by unique personal identifiers to develop a cohort of pneumonia diagnoses that occurred during each month a recruit was in training.

Medical encounter data are routinely generated within the Composite Health Care System at fixed-military treatment facilities; these records consist of ambulatory encounters and inpatient discharges. Ambulatory pneumonia encounters and inpatient discharges were identified using the International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) codes. Subject-matter experts and preventive medicine physicians were consulted to create a list of ICD-9-CM codes commonly used in practice to document a pneumonia diagnosis; these codes range from specific bacterial or viral diagnoses that may identify the causative agent, to more generalized codes that document an unspecified pneumonia. For the purposes of this assessment, the codes were grouped into four categories for descriptive analytics, as shown in Table I.

Ambulatory pneumonia encounters and inpatient discharges were analyzed separately and defined using a 30-day gap-in-care rule. Any record within 30 days of another record for the same person was considered part of the same encounter or discharge. If an individual received two differing pneumonia diagnoses (viral or bacterial) from an encounter or discharge within the same 30-day period, a hierarchy was used to categorize the type of pneumonia. Ambulatory encounters and inpatient discharges resulting in a diagnosis from pneumonia with influenza were prioritized above all other organisms, as these codes specifically document an influenza diagnosis with a secondary pneumonia infection. Second, if a recruit had two diagnosis codes for both viral and bacterial pneumonia within the same 30-day period, the encounter or discharge was classified as "viral and bacterial." Third, if the recruit had either a viral or bacterial pneumonia diagnosis within a 30-day period, the encounter/discharge was categorized into the respective category as either "viral" or "bacterial." Among recruits classified as either viral or bacterial diagnosis, ICD-9-CM code extenders further described the causative organism where possible. Encounters and discharges with dual bacterial

TABLE I. ICD-9-CM Codes and Pneumonia Classification Categories

Pneumonia Classification	ICD-9-CM Code
Pneumonia With Influenza	487.0, 488.01, 488.11, 488.81
Viral Pneumonia and Bacterial Pneumonia	480[a] and One of the Following: 481, 482[a], 483.0, 483.1
Viral Pneumonia	480[a]
Bacterial Pneumonia	481, 482[a], 483.0, 483.1
Pneumonia Resulting From Unspecified Organism	483.8, 485, 486

[a]All ICD-9-CM extenders.

TABLE II. Classification of Inpatient Discharges and Ambulatory Encounters for Pneumonia at MCRD Parris Island and San Diego, Marine Corps Recruits, 2007–2014

	MCRD Parris Island (n = 7,703)				MCRD San Diego (n = 20,040)			
	Inpatient (n = 507)		Ambulatory (n = 7,196)		Inpatient (n = 583)		Ambulatory (n = 19,457)	
	N	%	*N*	%	*N*	%	*N*	%
Influenza With Pneumonia	14	2.8	18	0.3	10	1.7	8	0.0
Dual Viral and Bacterial Diagnoses	3	0.6	4	0.1	1	0.2	7	0.0
Bacterial[a]	31	6.1	86	1.2	54	9.3	173	0.9
Pneumococcal pneumonia	2	—	30	—	22	—	99	—
Mycoplasma spp.	12	—	33	—	4	—	14	—
Staphylococcus spp.	2	—	2	—	13	—	10	—
Pseudomonas	4	—	4	—	4	—	4	—
Streptococcus spp.	3	—	4	—	3	—	2	—
Haemophilus influenzae	4	—	4	—	2	—	1	—
Klebsiella	1	—	1	—	0	—	0	—
Escherichia coli	1	—	1	—	0	—	0	—
Unspecified Bacteria	2	—	9	—	8	—	45	—
Viral[a]	26	5.1	19	0.3	17	2.9	65	0.3
Adenovirus	19	—	9	—	7	—	6	—
Respiratory Syncytial Virus	0	—	0	—	0	—	1	—
Parainfluenza	1	—	0	—	0	—	0	—
Unspecified Virus	6	—	10	—	10	—	58	—
Unspecified Pneumonia	433	85.4	7,069	98.2	501	85.9	19,204	98.7

[a]Bacterial and viral subcategories may not equal respective totals because encounters/discharges may include more than 1 diagnosis within 30 days.

and viral diagnoses within the 30-day case time frame are not further characterized because of conflicting diagnoses. Finally, ICD-9-CM codes with an unspecific pneumonia diagnosis were categorized as "unspecified." Refer to Table I for a complete listing of ICD-9-CM codes and respective categorizations.

Monthly pneumonia rates were calculated using the total number of ambulatory encounters and inpatient discharges divided by the aggregate number of recruits identified in the recruit rosters and are expressed per 1,000 recruit-months. Regression analyses were used to describe significant trend changes by month during the 8-year period. Spearman's correlation rank tests were also used to describe the relationship between inpatient and ambulatory encounter trends at each location. All analyses were completed with SAS Version 9.4 (SAS Institute, Cary, NC).

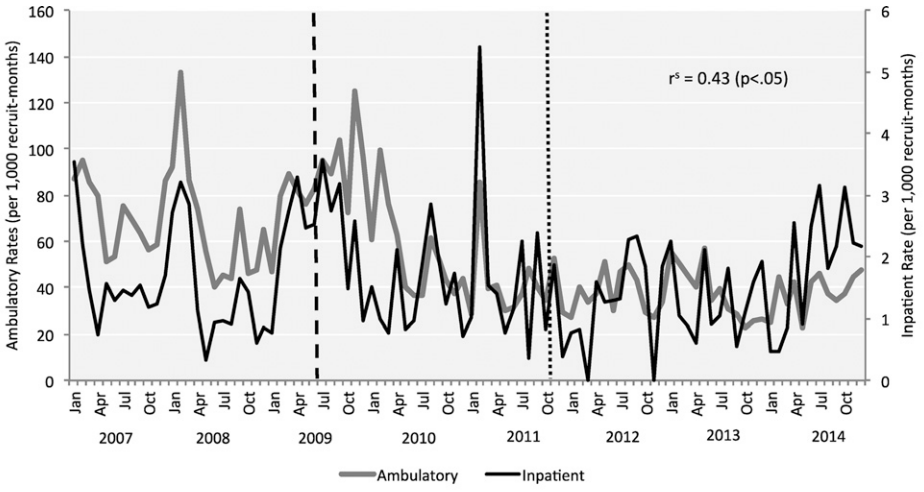
FINDINGS

A total of 250,713 Marine Corps recruits were identified in annual rosters from 2007 to 2014, representing 756,825 recruit-months. Overall recruit populations were larger at MCRD Parris Island, with a monthly average of 4,187 recruits compared to a monthly average of 3,696 recruits at San Diego. An estimated 26,653 ambulatory pneumonia encounters and 1,090 pneumonia inpatient discharges were identified using the previously defined 30-day case rule.

Among the inpatient discharges at MCRD Parris Island and San Diego, approximately 85% were attributed to an unspecified pneumonia diagnosis. The percentage of unknown causative agents was even greater in ambulatory encounters, where over 98% were identified as unspecified pneumonia illnesses at both locations (Table II). Specific ICD-9-CM codes and extenders are described in further detail where possible. Ambulatory encounters and inpatient discharges with dual bacterial and viral diagnosis codes within the 30-day case time frame are not further characterized here because of conflicting diagnoses.

Within the limited number of diagnoses that document a specific organism, the largest frequency of bacterial diagnoses at MCRD San Diego are attributed to pneumococcal pneumonia in both inpatient discharges (n = 22) and ambulatory encounters (n = 99). This observation was not demonstrated within MCRD Parris Island inpatient results, where pneumococcal pneumonia represented a small number of inpatient discharges (n = 2) and *Mycoplasma pneumonia* represented the largest frequency (n = 12). Among ambulatory encounters at MCRD Parris Island, both *M. pneumonia* (n = 33) and pneumococcal pneumonia (n = 30) account for the majority of known bacterial diagnoses. Within viral diagnoses, the largest frequencies are attributed to either adenovirus or an unspecified virus at both locations (Table II).

Pneumonia rates at MCRD San Diego and Parris Island are graphically presented in Figures 1 and 2, respectively; inpatient rates are depicted on the right-side y axis and ambulatory rates are represented on the left-side y axis. Two vertical lines are included in these figures to mark historical events; the vertical dashed line represents the month in which the World Health Organization signaled the start of the global influenza pandemic underway, and the dotted line shows the month in which the adenovirus vaccine was



ambulatory trend = 80.8805 - (0.5462 * unit month increase); p < .0001

inpatient trend = 1.7323 - (0.0022 * unit month increase); p = 0.5143

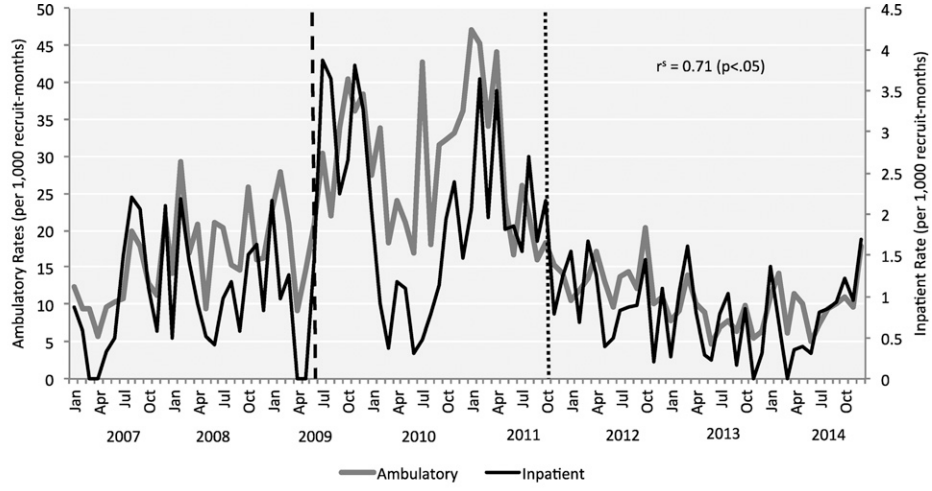
Dashed line represents WHO declaration of the 2009 influenza pandemic; dotted line represents re-instatement of the adenovirus vaccine.

Data are from the Comprehensive Ambulatory Professional Encounter Record (CAPER) and the Standard Inpatient Data Record databases (SIDR.)

FIGURE 1. MCRD San Diego ambulatory and inpatient pneumonia rates (per 1,000 recruit-months) by month, Marine Corps Recruits, 2007–2014.

reinstated. Although these are two important historical markers to understand in context of the trends in this report, it is important to note that any increase or decline in rates cannot be solely attributed to either event.

At MCRD San Diego, peak trends are observed during the winter months from 2007 to 2011 and more recently during 2014. Both inpatient and ambulatory trends during 2009–2010 exhibit a prolonged period of elevation throughout warmer months. Following reimplementation of the adenovirus vaccine during October 2011, ambulatory trends did not return to maximum rates observed in previous years, and the average rate following reimplementation (38.02 per 1,000 recruit-months) was nearly half the average rate before utilization of the adenovirus vaccine (65.59 per 1,000 recruit-months). In addition, inpatient trends demonstrated lower peak rates following implementation of the adenovirus



ambulatory trend = 23.0737 - (0.1052 * unit month increase); p = 0.0046

inpatient trend = 1.4815 - (0.0054 * unit month increase); p = 0.1069

Dashed line represents WHO declaration of the 2009 influenza pandemic; dotted line represents re-instatement of the adenovirus vaccine.

Data are from the Comprehensive Ambulatory Professional Encounter Record (CAPER) and the Standard Inpatient Data Record databases (SIDR.)

FIGURE 2. MCRD Parris Island ambulatory and inpatient pneumonia rates (per 1,000 recruit-months) by month, Marine Corps Recruits, 2007–2014.

vaccine, with the exception of observed increases during 2014. The difference between average inpatient rates for pre- (1.74 per 1,000 recruit-months) and postadenovirus vaccine periods (1.45 per 1,000 recruit-months) was not as large as observed for outpatient rates. Tests for linear trend applied to the entire 8-year period indicate that ambulatory rates declined significantly and ranged from 22.8 per 1,000 recruit-months to 133.5 per 1,000 recruit-months ($p < 0.05$). Concurrently, inpatient rates did not significantly decline ($p = 0.51$) and demonstrate less variability, ranging from 0 to 5.4 per 1,000 recruit-months. Correlation analyses indicate the relationship between inpatient and ambulatory rates at MCRD San Diego are weakly associated ($r^s = 0.43$; $p < 0.05$).

At MCRD Parris Island, seasonal fluctuations in pneumonia rates are not observed as they are at MCRD San Diego. A distinct period of prolonged peaks within both inpatient and ambulatory rates is observed from mid-2009 to mid-2011. Inpatient and ambulatory rates declined mid-2011 and did not return to peak levels following reimplementation of the adenovirus vaccine in October 2011. The average ambulatory rate following reimplementation (10.9 per 1,000 recruit-months) was approximately half the average rate before utilization of the adenovirus vaccine (22.8 per 1,000 recruit-months), and a smaller decline was observed among inpatient rates, falling from 1.48 per 1,000 recruit-months during the preadenovirus vaccine period to 0.83 per 1,000 recruit-months after reimplementation. Tests for linear trend applied to the 8-year observation period indicate that ambulatory rates declined significantly at MCRD Parris Island, ranging from 4.7 per 1,000 recruit-months to 47.1 per 1,000 recruit-months ($p < 0.05$). Inpatient rates demonstrated less variability, ranging from 0 to 3.9 per 1,000 recruit-months, with no significant change in trend ($p = 0.11$). Correlation analyses indicate the relationship between inpatient and ambulatory rates at MCRD Parris Island are positively associated ($r^s = 0.71$; $p < 0.05$).

DISCUSSION

Significant declines in ambulatory pneumonia rates were observed at both MCRD Parris Island and San Diego between 2007 and 2014, a period which included reinstatement of the adenovirus vaccine in late 2011. These findings mirror a recent study conducted by the Naval Health Research Center (NHRC), which found 100-fold declines in adenovirus disease burden among U.S. military recruits at eight training sites 2 years after reintroduction of the vaccine.[15] MCRDs Parris Island and San Diego represented two of the eight recruit centers included in the NHRC study, which was performed on the basis of collection and results of pharyngeal swabs from ill patients. Although the current study cannot assess trend changes resulting from specific causative organisms, our results indicate ambulatory encounter data from diagnostic ICD-9-CM codes align with trends demonstrated from laboratory-based data at the same locations.

During the same time period, however, inpatient pneumonia trends demonstrated within our study are not congruent with current literature. The aforementioned NHRC study estimates that reinstatement of the adenovirus vaccine prevented approximately 1,100 to 2,700 hospitalizations in military recruit training centers per year.[15] Our results do not support this evidence at either depot, where linear trends in pneumonia inpatient discharge rates did not significantly decline throughout the study, a period that included three years following reinstatement of the adenovirus vaccine.

Both depots experienced prolonged, heightened pneumonia trends from early 2009 to 2010. In June 2009, the World Health Organization signaled a global influenza pandemic underway, caused by a novel swine influenza A (H1N1) virus.[16] An internal report developed in 2010 by the Navy and Marine Corps Public Health Center documents an analysis of H1N1 cases in the Department of the Navy, describing recruits as a large proportion of reported cases among persons 15 to 19 years of age. The report further describes the implementation of mass testing practices for all individuals within operational units and recruit training centers who may have been exposed during outbreaks during this time, as a result of heightened concern for disease spread in high-risk environments characterized by close living quarters. This aggressive approach to laboratory testing likely attributed to an increase in clinical encounters, particularly among units where mass-testing practices occurred for early clinical diagnosis and treatment. Subsequently, the burden of pneumonia encounters during the time span of the 2009 H1N1 pandemic may have occurred as health care utilization increased for patients who normally might not have sought care, as well as heightened caution for detecting severe complications associated with influenza infection.

Crowding may increase the likelihood for person-to-person transmission of respiratory pathogens, but larger populations may also play a role in maintenance and increase of a pathogen in the environmental reservoir. A recent study demonstrated this relationship by assessing the effects of social distancing on respiratory pathogen transmission in a military recruit setting and found that the primary source of transmission was more likely from environmental exposures (such as contaminated surfaces) than person-to-person contact.[3] An additional study assessing the epidemic of febrile respiratory illness among military trainees concluded that new recruits did not introduce adenovirus into training facilities, instead the virus was likely introduced by others already in training or from environmental sources, such as air filters in barracks where adenovirus was isolated.[4] These findings raise further questions when applied to our results, where the mean recruit population at MCRD Parris Island was larger than MCRD San Diego, but demonstrated decreased pneumonia burden. Furthermore, differences in hygiene practices among recruits at MCRD Parris

Island may vary by gender. The U.S. Army Public Health Command provides recommendations for nonvaccine preventive measures, including administrative controls and personal measures, such as person-space requirements, isolation of infectious cases, hand hygiene, and cough/sneezing etiquette.[17] Both recruit facilities use these recommendations for preventive measures and also implement additional measures when needed for pneumonia control. Further assessment would be necessary to fully evaluate the relationship between overall recruit population and social distancing measures with pneumonia burden at each depot, as well as any differences in environmental exposures.

Both MCRD Parris Island and San Diego maintain long-standing preventive public health measures for pneumonia and other respiratory diseases, but have dissimilarities regarding the administration of pneumococcal vaccines and streptococcal prophylaxis. MCRD San Diego implements the pneumococcal vaccine to all recruits within the first 2 days of arrival, whereas MCRD Parris Island does not routinely administer this vaccine. A large meta-analysis evaluating the efficacy and effectiveness of pneumococcal polysaccharide vaccines demonstrated strong evidence of protection against culture-confirmed, invasive disease from randomized clinical trials, but not for all-cause pneumonia.[18] In our study, ambulatory rates may serve as a proxy for all-cause pneumonia and inpatient rates represent a measure for invasive disease. The weak correlation between inpatient and ambulatory rates at MCRD San Diego could potentially support the results from the meta-analysis, where trends for severe pneumonia did not significantly follow those for all-cause pneumonia. Furthermore, ambulatory pneumonia trends at MCRD San Diego far exceed those demonstrated at MCRD Parris Island, whereas inpatient rates at both locations are relatively comparable. This contrast raises questions as to what public health measures, if any, might be contributing to the lack of increase in inpatient rates at MCRD San Diego during periods of sustained and high all-cause pneumonia disease. These results may suggest pneumococcal vaccination and/or more intensive Bicillin prophylaxis could contribute to preventing severe, bacterial pneumonia incidence; however, a defined, systematic review of these public health measures for the prevention of invasive disease versus all-cause pneumonia would be warranted to further support this hypothesis.

The dissimilarity in GAS prophylaxis practices at these 2 locations also merits discussion. An internal report completed by Wendi Bowman, MPH, and Asha Riegodedios, MSPH, at the Navy and Marine Corps Public Health Center was compiled in 2012 to document a compendium of existing knowledge around group A beta-hemolytic *Streptococcus* in recruit settings. This report indicates MCRD Parris Island instituted a cold weather standard operating procedure before the winter of 2009, providing a second dose of prophylaxis for recruits passing their fourth training week from October to March. This decision was made on the basis of past years' surveillance and tracking of streptococcal trends at the depot. Subsequently, the report documents GAS infection rates for the winters 2009 and 2010 fell below 1 case per 1,000 recruits, down from peak rates of 8.5 cases per 1,000 recruits in December 2008. Our encounter-based trends do report heightened peaks of pneumonia rates during winter months of 2008 at MCRD Parris Island, but even larger peaks were observed during the two winters following, inverse of the local-level surveillance reports of declining GAS infection rates. Conversely, MCRD San Diego administers three doses of Bicillin throughout training and, therefore, the internal report by Bowman et al documents a GAS baseline rate of nearly zero with a few scattered weeks of minimal occurrences (1 case per 1,000 recruits). As with Parris Island, MCRD San Diego GAS rates do not appear to be congruent with the pneumonia trends reported in this assessment.

This assessment cannot describe a nonbiased comparison between pneumonia rates at the two locations because of potential dissimilarities within point-of-care decisions for hospital admissions and variability in coding practices.[19] However, the sheer difference in ambulatory pneumonia rates at MCRD San Diego versus Parris Island are worth noting, considering the potential impact of vaccination, prophylaxis, and environmental exposures previously discussed. These observations underscore the evidence that pneumonia burden in recruit locations, particularly at MCRD San Diego, is not associated with one single etiology. Recruits are at risk for a range of etiologic agents and control measures should include a combination of specific medical countermeasures that focus on a single bacterial or viral disease as well as nonmedical public health measures that reduce the overall burden of circulating infectious respiratory agents. Further study in particular of social and environmental factors may be warranted to understand the high ambulatory rates at MCRD San Diego to identify additional potential mitigation measures.

Several limitations from this study are worth noting. A large proportion of the recruits in the analysis indicated diagnoses of unspecified pneumonia types (either bacterial or viral). The nonspecific diagnoses may be a reflection of practice, where a provider presumptively diagnoses patients on the basis of symptoms and potential exposure from the recruit environment, pending further laboratory testing. At point of care, or initial encounter, the causative agent is likely not known. Furthermore, laboratory testing may not be performed when a diagnosis is made on radiological evidence (e.g., infiltrates) or physical signs (e.g., rales) and disease progression. In addition, many respiratory infections go undiagnosed, which poses a limitation in using ICD-9-CM diagnostic codes to estimate the burden of pneumonia among recruits. However, this limitation should not present challenges in evaluation of trends, as it would likely be consistent over time. In one study, data comparing active surveillance with clinic-based surveillance suggested that

approximately 69% of recruits with a fever and respiratory symptoms were not captured by clinic-based surveillance.[6]

If clinical care for a recruit took place at nonmilitary health system facilities (e.g., community hospital), the records associated with the encounter or admission are not included in this data source, therefore presenting potential for underestimation of ambulatory encounters and inpatient discharges. Although recruits at MCRD San Diego are more likely to be treated within the military health system, recruits at MCRD Parris Island that are admitted to Naval Hospital Beaufort are at times referred to a tertiary care facility as a part of local health care agreements.

This study did not stratify pneumonia trends by gender at MCRD Parris Island. As previously stated, differences in hygiene practices among recruits at this depot may vary by gender. Future analyses including stratified results by gender could provide more substantial evidence for social or environmental factors contributing to higher rates observed at MCRD San Diego compared to MCRD Parris Island.

Furthermore, the data structure for ambulatory records changed during the time frame of this study. Starting in 2012, encounter data included the expansion from four diagnostic fields to 10. The number of diagnoses for a particular condition may appear to increase after January 1, 2012, even if the actual number of individuals with the condition did not. This change will affect ambulatory encounters and may make comparisons across years difficult to interpret. The inpatient data were not impacted. Data for medical surveillance are considered provisional and diagnoses may change if the record is updated after the report is generated; however, this limitation is likely minimal as our methods select the most updated records for analysis. In addition, data provided by the Defense Manpower Data Center to identify recruit individuals and calculate rates are monthly snapshots of service members' personnel records. Changes in a service member's status after the monthly data are extracted will not be reflected until the following month.

In summary, this study underscores the importance for broad control measures that are not etiology dependent to control pneumonia in recruit training centers. Although this assessment cannot describe morbidity on the basis of specific organisms, these data still lend several noteworthy trends as they relate to differences and similarities in vaccination and prophylaxis policies at MCRD San Diego and Parris Island. Linear trends in pneumonia ambulatory rates significantly declined at both locations between 2007 and 2014, a period that included reinstatement of the adenovirus vaccine. Monthly ambulatory and inpatient trends at MCRD Parris Island were highly correlated during the study period, but a weaker correlation at MCRD San Diego suggests that trends for potentially severe pneumonia do not follow those for generalized disease. These trends, coupled with the similarities and dissimilarities for public health prevention practices at each depot, may warrant further investigation for a systematic review of pneumonia control at both locations.

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