Gastrointestinal Disease in Pilots, 2001–2013

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INTRODUCTION: The frequency and distribution of gastrointestinal (GI) disease in the population of active duty Air Force pilots is poorly understood, even though GI illness can temporarily or permanently lead to disqualification from flying duties. Better understanding of GI disease within this population could yield considerable operational risk and human performance insight and provide data to use in assessing the effectiveness of current medical standards related to flight training and flying duties.

METHODS: A dataset reflecting inpatient and outpatient healthcare visits from 2001 through 2013 was developed and reviewed. Gastrointestinal illness was grouped into 18 subcategories of disease, and the frequency and distribution of visits for these categories were tallied. The total burden of GI illness over the target dates was compared between pilots, nonpilot aircrew/special operational duty personnel, and nonaircrew/nonspecial duty personnel.

RESULTS: Esophageal disease and dyspeptic conditions were the two most frequently encountered diagnoses among all three population groups, comprising almost 50% of the gastrointestinal diagnoses in age and gender-matched samples of all three populations. The overall burden of disease over the total timeframe of the study was not statistically different in the three populations, with a median of four encounters per person for GI disease. Of interest, the total burden of disease increased over the course of the study period in all populations, driven in large measure by increases in esophageal disease and dyspeptic conditions.

DISCUSSION: The general distribution and overall burden of GI disease in populations of Air Force pilots, nonpilot aircrew/special operational duty personnel, and nonaircrew/nonspecial duty personnel were similar. The increase in esophageal and dyspeptic conditions over time warrants further attention.

KEYWORDS: gastrointestinal, pilots, Air Force, burden of disease.

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Since the early days of flight, medical standards have been applied to aviators in an effort to improve flying safety. At the time of U.S. mobilization for World War I, Major Theodore Charles Lyster, with the help of colleagues, was given the task of establishing examination centers and administering tests to pilots, applying medical standards that were stricter for pilots than for ground-based personnel. On 18 October 1917, the War Department established a Medical Research Board that was given the authority to act as a standing medical board for the consideration of all matters relating to the physical fitness of pilots.[11]

At present, medical standards are applied to ensure the accession and retention of members who are medically acceptable for military duty, and these standards apply to all U.S. Air Force (USAF) members. Medical conditions are considered disqualifying for aviation when they have the potential to negatively impact flight safety, and waiver consideration for disqualifying conditions requires that the condition be compatible with the performance of sustained flying operations and be resolved or stable and expected to remain so under the stresses of the aviation environment.[15] The application of accession, retention, and aviation/special operational duty standards might thus be expected to impact the burden of certain disease conditions within the community of USAF pilots when those disease conditions have the potential to impair general military or aviation duty performance. In addition, it has been reasonably assumed that excluding or separating members with specified diseases and medical conditions renders the remaining force healthier and better able to perform their operational duties.

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Disease conditions impacting the gastrointestinal (GI) tract have the potential to produce sudden incapacitation, subtle performance degradation, and distraction to aircrew members. Acute GI hemorrhage, for instance, can induce hemodynamic instability, impaired oxygen-carrying capacity, and distraction suitable to render a pilot acutely incapable of controlling an aircraft. Chronic and progressive anemia resulting from slow GI blood loss can result in impaired tolerance of hypoxia, reduced exercise tolerance, and subtle performance degradation that can negatively impact pilot effectiveness. Distraction as a result of painful gaseous abdominal distention at altitude, or the untimely release of incontinent stool, can significantly impair the performance of even the most focused pilot.

A number of published studies describe specific disease conditions within aircrew populations. Some examples include assessments of cardiac event rates in USAF aviators,[9] prevalence of coronary atherosclerosis in healthy UK aviators,[14] and primary idiopathic optic neuritis in USAF aviators,[7] but there is little information available about the frequency and distribution of GI illness in USAF aircrew members. A 2003 study reviewed the Navy waiver experience for aviators with hepatitis,[4] and Vasiliev assessed morbidity rate and early diagnosis of GI tract illness in Russian aircrew,[18] but a literature review failed to reveal additional references to any of a broad range of GI illnesses in a USAF pilot population.

In this study we accessed Air Force data systems to identify GI diagnoses in active duty USAF pilots and in those active duty Air Force airmen who did not perform pilot duties over the target dates of 2001–2013. The goal was to describe the frequency and distribution of GI tract illness in these populations and to compare the burden of GI disease between the pilot population and two nonpilot active duty populations.

METHODS

Subjects

The Military Health System Mart (M2) contains data related to healthcare usage by active duty military members. Diagnoses are recorded by International Classification of Diseases, Ninth Revision (ICD-9) codes, whether provided in the inpatient or outpatient setting, in or outside of medical treatment facilities. Using M2, we collected data for calendar years 2001 through 2013 related to the following variables: Social Security number (SSN) for merging purposes, date of birth (DOB), dates of care, and ICD-9 diagnosis codes. Diagnosis codes of specific interest included the following: 530-539 (esophagus, stomach, and duodenum), 555-558 (noninfectious enteritis and colitis), 560-569 (other diseases of the intestines and peritoneum), and 570-579 (other diseases of the digestive system), based on the ICD-9 Clinical Modification Manual, Standard Edition. All diagnoses listed as primary diagnoses or additional diagnoses were considered.

Active duty personnel are categorized by their Air Force Specialty Code (AFSC), which specifies their occupation within the Air Force. We collected the following data from the Air Force Personnel Center (AFPC): duty AFSC, primary AFSC, SSN for merging purposes, DOB to calculate age, and rank. Data from M2 were merged with data from AFPC using SSN. Once the datasets were merged and age calculated, SSN and DOB were removed from the merged dataset, producing a de-identified dataset for the purposes of this study.

Procedure

This was a descriptive cohort study, comparing frequency and distribution of GI illness in: 1) active duty Air Force pilots, 2) nonpilot aircrew and Special Operational Duty (SOD) personnel, and 3) those active duty members not designated as rated aircrew or SOD personnel. The sample population consisted of all active duty members. The study population was broken down as described above. The target population was active duty Air Force pilots. Pilots were defined as those carrying an AFSC of 11X, where the "X" stands for additional pilot designator codes; nonpilot aircrew/SOD were defined as those carrying AFSCs of 12X, 13X, 18X, 1AX, 1TX, 1UX, 1WX, 43X, 46X, 48X, 4MX, and 4NX (not 4N1). Members with the remaining AFSCs constituted the remaining population. The applicable gastroenterology ICD-9 codes, as described above, were grouped into 18 general categories for convenience and consistency in review. Those categories are presented in **Table I**.

Nonpilot aircrew and SOD personnel were considered a separate population in the analysis since the aircrew medical standards described in Air Force Instruction 48-123, Chapter 6, and articulated in the Air Force Medical Standards Directory are applied to these individuals as well as to trained pilots. Since the focus of this effort was directed at those aircrew members in operational control of the aircraft, separating the nonpilot aircrew and SOD personnel from the pilot population would ensure that distinctions related to both occupation and the application of medical standards would be revealed. After reviewing data from the total populations, age- and gender-matched subpopulations were analyzed to exclude the impact of age and gender on study findings.

The burden of disease, for the purposes of this study, was defined as encounters with a specified GI diagnosis over a targeted period of time. Overall burden of disease for the study period (2001–2013) and burden of disease per individual year were calculated for each population. The goal of the study was to understand the frequency and distribution of gastrointestinal disease in Air Force pilots over time.

Statistical Analysis

The SAS statistical software package (SAS Institute, Cary, NC) was used as the computational tool in this study. Age- and gender-matched subpopulations were developed for analysis. The pilot population was the smallest; therefore, it was used to match birth month, year, and gender to the other two datasets and provide three smaller sets of data where every element had a complement in all of the other sets. Only three-way matches were kept. As only officers may hold 11X (pilot) AFSCs, we limited the age criteria for the pilot group to 22 yr and older to avoid categorization errors resulting in individuals labeled as pilots, yet too young to actually serve in this capacity.

Table I. Disease Categories/Distribution, Total Population.

	PILOT INCIDENTS		NON-FLYER INCIDENTS		AIRCREW NON-PILOT	
	162,857		4,382,019		472,919	
DIAGNOSES	**FREQ.**	**%**	**FREQ.**	**%**	**FREQ.**	**%**
Esophageal Disease	30,770	18.89	860,295	19.63	101,619	21.49
Dyspeptic Conditions	23,583	14.48	935,613	21.35	86,633	18.32
Nonspecific Conditions	18,524	11.37	316,297	7.22	37,449	7.92
Functional Disorders	11,723	7.20	455,637	10.40	41,657	8.81
Biliary Disease	10,912	6.70	285,041	6.50	30,885	6.53
Gastrointestinal Hemorrhage	10,417	6.40	277,579	6.33	29,917	6.33
Diverticular Disease	10,413	6.39	151,676	3.46	21,948	4.64
Inflammatory Bowel Disease	9330	5.73	191,792	4.38	18,253	3.86
Hepatic Disease	7043	4.32	156,166	3.56	19,191	4.06
Colonic Disease	4750	2.92	101,671	2.32	10,477	2.22
Colon Polyps	3991	2.45	61,041	1.39	9035	1.91
Surgical GI Conditions	3323	2.04	73,849	1.69	8232	1.74
Pancreatic Disease	3011	1.85	92,538	2.11	12,643	2.67
Malabsorption	1740	1.07	18,048	0.41	3873	0.82
Peptic Ulcer Disease	1315	0.81	37,017	0.84	4549	0.96
Benign Neoplasms of the GI System	696	0.43	12,780	0.29	1840	0.39
Colon Cancer	240	0.15	3427	0.08	587	0.12
Malignant Neoplasm	37	0.02	1103	0.03	389	0.08

Correspondingly, only those individuals 22 yr and older in the other populations were chosen. This excluded many young enlisted airmen from the study, but the integrity of the research was maintained by having the same population characteristics in terms of each age and gender in all three matched data groups.

Chi-squared tests were performed on the data as the independent variable was categorical and the dependent variable was frequency (ordinal), with a *P*-value of 0.05 chosen to demonstrate statistical significance in a two-sided test. Each group was tested against the others for a total of three sets of tests between subpopulations, against each category of GI disease. Finally an overall test of disease vs. no disease was performed for the three subpopulations using the Chi-squared method. The study protocol was approved by the Institutional Review Board of the Air Force Research Laboratory, Wright-Patterson Air Force Base, OH, and a data use agreement was secured from AF/SG6, for access to M2 and AFPC data.

RESULTS

The dataset developed for study review contained data reflecting over five million medical encounters. Demographics of the study population reveal pilots to be older, predominantly male, and of higher rank than the other populations. There were 8762 pilots with medical encounters listing a GI diagnosis over the period of the study, compared to 38,709 nonpilot aircrew/SOD and 385,834 nonaircrew/non-SOD. Table I shows the breakdown of the total population by diagnostic category, ranked from most to least frequently encountered diagnostic group. The category of esophageal disease, which includes diagnoses of reflux esophagitis, eosinophilic esophagitis, Barrett's esophagus, and all other inflammatory, ulcerative, motility-based, or "other" diseases of the esophagus, was the most frequently encountered diagnostic category in all three populations, followed by dyspeptic conditions, which include gastritis and duodenitis. Peptic ulcer disease (gastric and duodenal) was considered a different diagnostic category and was not among the top 10 categories in any of the 3 populations.

Table II shows age- and gender-matched data, again revealing dyspeptic conditions and esophageal disease to be the top two disease categories, accounting for nearly half of the encounters in each population. Comparing pilots to nonaircrew/non-SOD, colon polyps, diverticular disease, and dyspeptic conditions were encountered significantly more often in pilots than in nonaircrew/non-SOD, but esophageal disease, functional disorders, and biliary disease were encountered less often. Comparing pilots to nonpilot aircrew/SOD, anorectal disease, diverticular disease, dyspepsia, and inflammatory bowel disease were encountered more frequently in pilots, while esophageal disease was encountered less often.

The overall burden of disease over the total timeframe of the study, 2001–2013, was not statistically different in the three populations, with a median of four encounters per person for GI disease. The range is quite broad, with up to 1881 encounters appreciated in 1 pilot, and similarly high encounter numbers in the other populations. **Fig. 1** displays the burden of disease over time in the three populations, demonstrating an increasing number of encounters for GI disease per year in each of the three populations. When stratified by population and major organ system (upper GI tract conditions, lower GI tract conditions, hepatobiliary/pancreatic conditions) in **Fig. 2**, **Fig. 3**, and **Fig. 4**, the increases are most pronounced for categories of upper GI conditions in all three populations.

DISCUSSION

The frequency and distribution of GI disease are roughly equivalent in the populations of pilots, nonpilot aircrew/SOD, and

Table II. Disease Categories/Distribution, Age/Gender-Matched Population.*

	PILOTS		NON-AVIATOR		AIRCREW NON-PILOT	
	5700		5635		5684	
DIAGNOSES	**FREQ.**	**%**	**FREQ.**	**%**	**FREQ.**	**%**
Dyspeptic Conditions	1716	30.11	1523	27.03	1407	24.75
Esophageal Disease	1006	17.65	1274	22.61	1393	24.51
Nonspecific Conditions	603	10.58	537	9.53	489	8.60
Functional Disorders	428	7.51	443	7.86	493	8.67
Diverticular Disease	362	6.35	310	5.50	316	5.56
Gastrointestinal Hemorrhage	343	6.02	322	5.71	336	5.91
Biliary Disease	201	3.53	226	4.01	211	3.71
Colonic Disease	171	3.00	126	2.24	133	2.34
Colon Polyps	167	2.93	156	2.77	150	2.64
Hepatic Disease	164	2.88	207	3.67	228	4.01
Inflammatory Bowel Disease	88	1.54	67	1.19	52	0.91
Surgical GI Conditions	61	1.07	51	0.91	46	0.81
Pancreatic Disease	32	0.56	46	0.82	45	0.79
Peptic Ulcer Disease	32	0.56	53	0.94	47	0.83
Malabsorption	20	0.35	18	0.32	15	0.26
Benign Neoplasms of the GI System	13	0.23	8	0.14	7	0.12
Colon Cancer	6	0.11	7	0.12	2	0.04
Malignant Neoplasm	0	0.00	0	0.00	0	0.00

* $N = 4673$ per group.

nonaircrew/non-SOD members. Statistical differences were noted in some categories of GI disease, such as esophageal disease and dyspeptic conditions, among others as outlined. These differences could reflect the impact that large numbers of encounters brings to statistical testing, or could be real differences and therefore worthy of additional study.

The methodology of using patient encounter data as the basis for assessing the frequency and distribution of disease has been used in other studies, such as a study of Naval aviators admitted to a Naval hospital.[8] In this population, inpatient diagnoses were identified and used as markers of disease burden in the aviator population. Perirectal abscess, appendicitis, and perianal condylomata represented GI diagnoses in that described cohort.[8] A study assessing age-specific morbidity among Navy pilots reviewed hospitalization rates by age for Naval aviators compared to nonpilot aircrew, unrestricted line officers, and staff officers.[6] Of interest, aircrew members and pilots had the highest hospitalization rates of the four groups. Diagnoses in the digestive disease category were the most frequently encountered in this study, but two-thirds of those admissions were for tooth development and eruption, categorized for the purposes of the study as a GI diagnosis.[6] Unlike the Navy study, the present study does not count tooth development and eruption as a GI diagnosis.

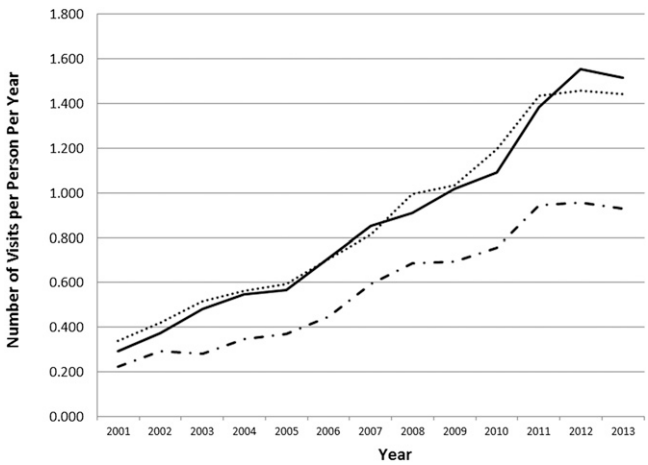

Fig. 1. Burden of disease over time. Solid line represents pilots, the dotted line represents non-flyers, and the dotted-dashed line represents aircrew non-pilots.

We were intrigued that esophageal disease and dyspepsia accounted for almost half of the encounters reported in all three age and gender-matched populations, and the encounters per person per year increased over the course of the study period. While this could reflect changes in coding trends, the slope of the line reflecting encounters per person per year was greater in upper GI tract conditions than in all others, suggesting that global changes in coding trends are unlikely to account for all of the differences. In an assessment of U.S. healthcare utilization in ambulatory and inpatient settings from 2007 through 2012, gastroesophageal reflux was the second most frequent diagnosis in ambulatory settings in 2010,[10] whereas gastroesophageal reflux was the highest ranking diagnosis for outpatient clinic visits in the United States in 2002.[12] Age adjusted rates of ambulatory care visits for gastroesophageal reflux disease also showed an increase over time from 1979 to 2004 in a U.S. National Ambulatory Medical Care Survey,[3] and a UK study demonstrated increases in most gastrointestinal diseases, citing a community based study reporting a prevalence of 28.7% for gastroesophageal reflux symptoms.[19]

The burden of disease, for the purposes of this study, was defined as encounters with a specified GI diagnosis over the targeted period of time. Using this definition, upper gastrointestinal tract diagnoses demonstrated a greater burden over time than lower gastrointestinal tract or biliary diseases, and the number of visits per person climbed at a greater rate for upper

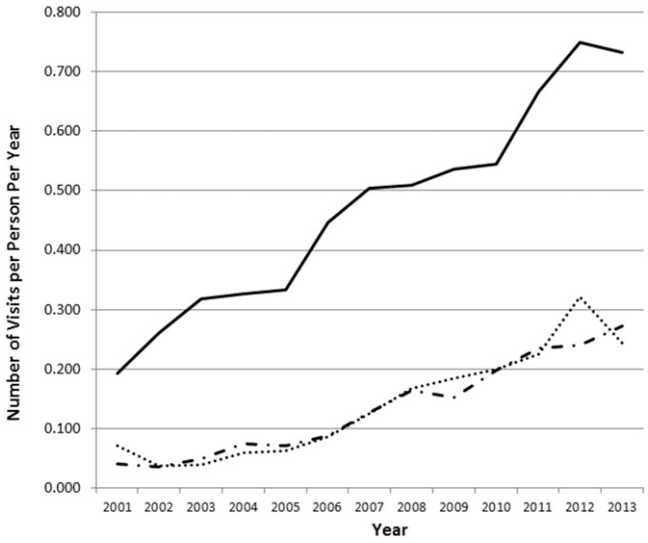

Fig. 2. Burden of disease in pilots. The solid line represents upper gastrointestinal tract diseases, the dotted line represents hepatobiliary/pancreatic diseases, and the dotted-dashed line represents lower gastrointestinal tract diseases.

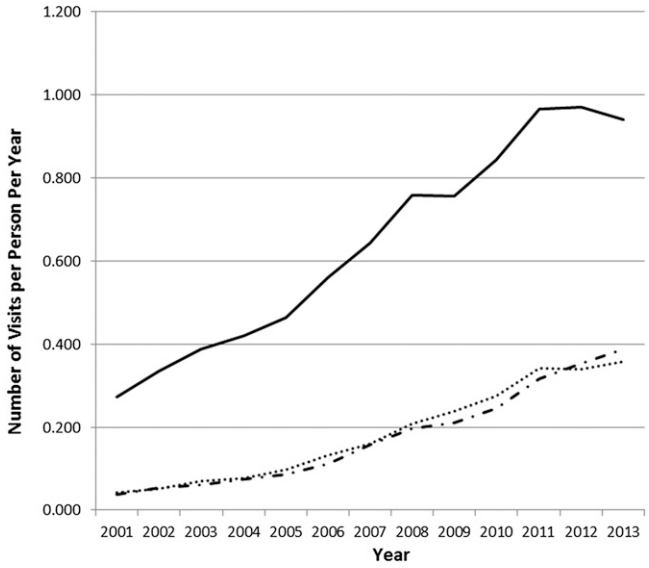

Fig. 4. Burden of disease in nonflyers. The solid line represents upper gastrointestinal tract diseases, the dotted line represents hepatobiliary/pancreatic diseases, and the dotted-dashed line represents lower gastrointestinal tract diseases.

gastrointestinal tract diseases than that noted for lower gastrointestinal tract or biliary disease. Using a broader definition for burden of disease, including prevalence, direct cost, and indirect cost, one investigator demonstrated that gastroesophageal reflux disease manifested the greatest burden of disease in the years 1998 and 2000, and that the burden increased over that 2-yr interval.[12] Data on outpatient visits for 2002, collected as part of the National Ambulatory Medical Care Survey, revealed that gastroesophageal reflux disease had passed abdominal pain as the principal gastroenterology-related provider diagnosis.[13]

Considerable energy is expended in the development and application of medical standards, whether dealing with a military population or other populations such as those engaged in commercial transportation[5] or maritime duties.[1] In all such career fields, the emphasis on fitness for duty is based on best available evidence supplemented by the professional opinion of subject matter experts, culminating in a risk assessment applied to the career field in question. When specifically applied to the Air Force, medical standards ensure the accession and retention of members who are medically acceptable for Air Force duty, based on both the disease condition and its severity and response to treatment. A waiver of stipulated standards for aircrew members is possible if a disqualifying condition meets the following criteria:[15]

1. Does not pose a risk of sudden incapacitation;
2. Poses minimal potential for subtle performance decrement, particularly with regard to the higher senses;
3. Can be resolved or is stable, and expected to remain so under the stresses of the aviation environment;
4. If the possibility of progression or recurrence exists, the first symptoms or signs must be easily detectable and not pose a risk to the individuals or the safety of others;
5. Cannot require exotic tests, regular invasive procedures, or frequent absences to monitor for stability or progression; and
6. Must be compatible with the performance of sustained flying operations.

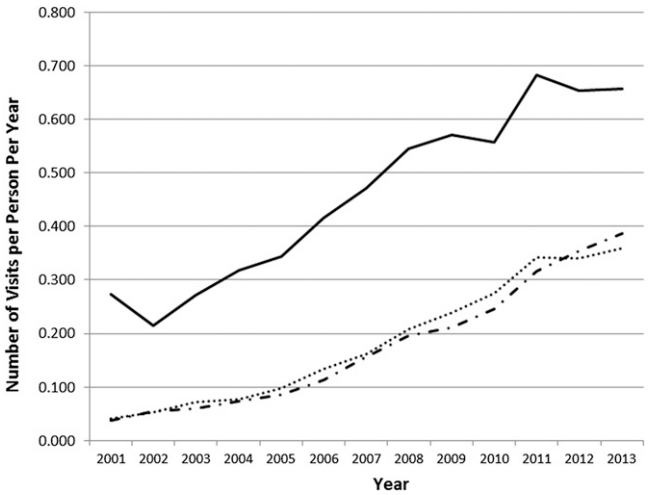

Fig. 3. Burden of disease in nonpilot aircrew. The solid line represents upper gastrointestinal tract diseases, the dotted line represents hepatobiliary/pancreatic diseases, and the dotted-dashed line represents lower gastrointestinal tract diseases.

DeHart[2] used the term "medical wastage" to refer to those rejected from flying training or rejected after becoming trained assets in his study of the Royal Australian Air Force, but GI diagnoses were not represented in the top 10 reasons for medical rejection of applicants. Out of 300 applicants rejected, a single case of chronic dyspepsia was the only GI diagnosis represented in the cohort. Among trained aircrew, 3 cases of GI illness were cited in the 53 members subjected to flying restrictions.[2] In this study, gastrointestinal conditions were described

with equal frequency in pilots and nonpilots, suggesting that the application of Air Force medical standards did not result in exclusion of pilots with gastrointestinal disease from assignment as a pilot. What is not clear from the available data is whether or not pilots, once diagnosed with a gastrointestinal condition, were removed from flying duties.

Flying class standards applied to pilot trainees and pilots (I and II) are more stringent than those imposed on nonaircrew/non-SOD members,[16] and yet the frequency and distribution of GI disease in the pilot population studied were similar to those in the nonpilot populations. In some instances, pilots with disqualifying conditions under written standards continue to serve in nonflying duties. In other instances, the presence of disease is waived according to the criteria outlined above, and when the aircrew member's condition is well-controlled by medications listed in the Official Air Force Aerospace Medicine Approved Medications list.[17] The dataset used in this study does not reveal whether members were actively engaged in flying duties at the time of their medical encounters, nor do the data reflect the aeromedical disposition applied to each aircrew member with GI disease. Further investigation into the flying status of pilots afflicted with GI disease and their specific aeromedical dispositions is warranted, and would provide considerable value in further assessing the operational impact of GI illness in the pilot population.

Any study that relies on the use of data from the retrospective review of encounter coding must recognize the limitations inherent in the use of coding data. The accuracy of coding data relies on the coding knowledge and interest of the coder. In military settings most coding is accomplished by the treating provider, and that individual may not be as facile or interested in coding accuracy as nonmilitary providers and professional coders. For instance, in this study the abundance of "non-specific conditions" may reflect either the gathered abundance of the small occurrences of the included disease conditions or a strategy that suggests application of a single grab-bag diagnosis to any presenting condition. The available de-identified dataset does not allow us to "dig down" into the individual records to clarify coding accuracy or discrepancies.

In conclusion, in the face of consistent application of selection and flying class standards, the frequency and distribution of gastrointestinal illness are roughly equivalent in the pilot, nonpilot aircrew/SOD, and nonaircrew/non-SOD populations. In addition, the burden of GI disease, although equivalent in each population over the timeframe of the study, demonstrates an increase in GI illness over time in all populations. The operational impact of gastrointestinal illnesses in aircrew warrants further investigation.

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