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SPECIAL ARTICLE

ENDAMOEBA HISTOLYTICA AND OTHER INTESTINAL PARASITES¹

INCIDENCE IN VARIOUSLY EXPOSED GROUPS OF THE NAVY

By Lieutenant J. J. Sapero, Medical Corps, United States Navy, and C. M. Johnson, Sc. D., Protozoologist²

An investigation has been conducted to determine the incidence of *Endamoeba histolytica* in Navy men stationed in the American tropics and the Orient where amebic dysentery is endemic, and to estimate the danger of carriers in the dissemination of amebiasis in the Navy, and in the general population of the United States. In addition, the findings regarding intestinal parasites other than *E. histolytica* have been of considerable interest and are included in the present report.

INTRODUCTION

There are many indications that the amebiasis problem is of particular naval interest. Some 10,000 men of the service are stationed in parts of the world where amebic dysentery is highly endemic. The chances for acquiring amebic infections incident to such duty appear to be considerable. In the American tropics where many of the men remain on duty for a 2- or 3-year period, naval activities bring men into contact with a region termed by James³ as "* * * one of the world's hotbeds of *histolytica* infection * * *." In the Orient where still larger numbers are stationed, amebic dysentery is even more prevalent.

In these parts of the world the combination of large numbers of carriers and the prevalence of insanitation greatly enhances the

¹ From the Gorgas Memorial Laboratory, Panama, Republic of Panama, with the technical assistance of Lester E. Boston, chief pharmacist's mate, and Martine H. Williams, pharmacist's mate, first class, both of the United States Navy.

² The authors wish to acknowledge the generous assistance of the many officers of the Line and Medical Corps of the Navy whose splendid cooperation made possible the present investigation.

³ James, W. M.: Human amebiasis due to infection with *Endamoeba histolytica*. *Ann. of Trop. Med. & Parasitol.*, 22: 201-258, August 1928.

danger of acquiring infections. Ashore, the men often obtain food and drink prepared under unclean conditions by infected foodhandlers. Aboard ship, fresh provisions grown and handled by natives are served to the crews when food from more reliable sources is not obtainable. Furthermore, it is possible that the presence of carriers aboard ship, particularly those who handle food, constitutes an important additional source of infection.

From the civilian standpoint the main interest concerns the return to the United States of carriers of amebic infection, for these are potential sources for the dissemination of amebiasis among the general population. Johnstone and his coworkers⁴ recently have stressed the epidemiological importance of such carriers, and Clark⁵ warns that too little attention has been given to the possibility of disease introduction by returning soldiers and sailors who have been on duty in the tropics. One of the purposes of the present investigation, therefore, has been to evaluate this aspect of the amebiasis problem.

METHODS

The largest number of the examinations were done in Panama, where it was possible to survey variously exposed groups of Navy men. Three ships from the special service squadron were included in the study, in order to secure data on intestinal parasitic infections incident to tropical service. Men returning from the Orient were surveyed while en route through the Panama Canal. The rate of dissemination aboard naval vessels was determined by an examination of men attached to submarines.

A control group was examined to obtain the infection incidence in men without foreign service. This work was done on recruits at the naval training station in Norfolk, Va., and included men from all parts of the United States.

The technique of fecal examination for all groups was similar. Three specimens were obtained from each man. A cathartic of 2 drams of fluid extract of cascara sagrada was administered prior to the collection of the first specimen. Most of the specimens were received within 2 or 3 hours after passage; a few were as much as 8 hours old.

Andrews⁶ states that conservatively estimated, a single purged stool reveals at least 75 percent of the protozoan species which might ultimately be discovered. The use of cathartics in the naval survey usually resulted in one or more of the specimens being of soft or mushy consistency, and therefore, it is believed that a large majority of the infections were detected.

⁴ Johnstone, H. G., David, N. A., and Reed, A. C.: A protozoal survey of one thousand prisoners. *J. A. M. A.*, 100: 728-731, March 1933.

⁵ Clark, H. C.: The development of international transportation and its effect on the practice of tropical medicine. *Am. J. Trop. Med.*, 18: 1-7, January 1938.

⁶ Andrews, J.: The diagnosis of intestinal protozoa from purged and normally-passed stools. *J. Parasit.*, 20: 253-254, June 1934.

The examinations of stools after cascara had the disadvantage of presenting the trophozoite to diagnose rather than the cystic form. Thus, for accuracy every diagnosis in the fresh saline preparation was checked by stained smears. For these, the rapid iron-hematoxylin method devised by Johnson⁷ was employed.

The thinness of the saline smears decreased the chances of detecting the helminthic infections, and as neither flotation nor centrifuging technics were employed, many of the helminths were doubtlessly missed.

RESULTS

Control group.—It is evident from the data presented in table 1 that a high percentage of men entering the Navy harbor the dysentery organism, this being particularly true for recruits coming from the southeastern United States. The 14.7 percent incidence of *E. histolytica* in men from the South is nearly twice that of the other group which included representatives from all other States. As a result of these examinations, it is apparent that not only a considerable percentage of infections found in any subsequently examined group will have been acquired prior to naval service, but that the number of such infections will depend on the proportions of men from the south and from other parts of the country. Thus, in making later comparisons and using the Norfolk group as a control, allowance has been made for these previously acquired infections.

TABLE 1

Intestinal parasites in Naval recruits—Control group

	Southern States	Other States
Total number of men examined.....	129	77
	<i>Percent</i>	<i>Percent</i>
Percentage of protozoal infections.....	63.6	48.1
Percentage of helminth infections.....	17.1	.....
<i>E. histolytica</i>	14.7	7.8
<i>E. coli</i>	39.5	29.6
<i>E. nana</i>	29.5	23.4
<i>I. bütschlii</i>	9.3	.....
<i>D. fragilis</i>	17.1	16.4
<i>G. lamblia</i>	7.8	5.2
<i>C. mesniti</i>	2.3	2.6
<i>T. hominis</i>	2.3	2.6
<i>N. americanus</i>	14.0	.....
<i>T. trichiura</i>	3.0	.....
Naval service: Average per man (weeks).....	3.9	28.0

There was a marked contrast in the other parasitic findings in the two groups. Of the southern recruits, 63.6 percent of the men harbored some protozoan, and 23 of these had multiple infections with three or more protozoal species. Often enormous numbers of each

⁷ Johnson, C. M.: A rapid technique for iron-hematoxylin staining requiring no microscopic control of decolorization. *Am. J. Trop. Med.*, 15: 551-563, September 1935.

protozoan would be encountered. In the "other States" group, less than one-half of the men were infected, and the intensities were correspondingly less.

All the helminthic infections were found in the southern recruits. *N. americanus* was the important species with an incidence of 14.0 percent.

Tropical exposure.—In table 2 the results of examinations are recorded for ships of the special service squadron. Each of the three vessels had been stationed in tropical waters for periods varying from 8 to 16 months. Two of the ships, destroyers, had made extended cruises throughout Central America, the men visiting both seaport and interior cities. At the squadron base in Panama, the important contacts were made ashore, usually in Panama City where the men frequently obtained food and drink in native eating establishments. Whether in Panama or in other Central American countries, the sanitary conditions encountered by the men were often unsatisfactory.

The total incidence of *E. histolytica* for the three ships was 9.5 percent. Although there had been considerable difference in the exposures of the crew of each individual ship, the infection rates for the three ships were practically the same. This suggests that no new infections had been acquired during this tropical duty. Furthermore, the rate for these men upon entry into the service may be estimated at 11 percent, an incidence representing the mid-point of the Norfolk extremes, as approximately one-half of the crews were enlisted in Southern States. Similarly, there was no evidence of dissemination within the crew of any ship, despite the presence of numerous carriers.

TABLE 2

Intestinal parasites in Navy men on tropical duty, special service squadron

	Gunboat	Destroyers		Squadron total
		A	B	
Number of men examined.....	218	129	125	472
	<i>Percent</i>	<i>Percent</i>	<i>Percent</i>	<i>Percent</i>
Protozoal infections.....	33.0	38.0	48.0	38.3
Helminth infections.....	5.0	1.6	6.4	4.5
<i>E. histolytica</i>	9.6	9.3	10.4	9.5
<i>E. coli</i>	16.1	19.4	28.6	20.5
<i>E. nana</i>	16.5	18.6	23.2	18.9
<i>I. bütschlii</i>	3.7	2.3	3.2	3.2
<i>D. fragilis</i>	3.2	2.3	6.4	3.8
<i>G. lamblia</i>	6.0	5.4	7.6	6.1
<i>C. mesnili</i>	1.4	.....	1.6	1.1
<i>T. hominis</i>.....	.5	.....	1.6	.6
<i>N. americanus</i>	3.7	.....	3.2	2.5
<i>S. stercoralis</i>.....	.....	.....	1.6	.4
<i>T. trichiura</i>.....	.9	.8	.....	.6
<i>T. hymenolepis nana</i>.....	.5	.....	1.6	.6
<i>A. lumbricoides</i>.....	.....	.8	.....	.2
Average length of tropical service, months.....	8	15	16	13

The helminthic infections were not numerous. Hookworms were encountered in 2.5 percent of the men. All of these cases appear to have resulted from previous residence in endemic hookworm centers of the United States.

Submarine group.—Although no evidence of dissemination was found on the larger naval vessels, the crews of six submarines were surveyed as it seemed likely that duty on this type of ship would predispose to transmission. The internal arrangement of the S-boats is such that strict sanitary supervision of the messes and foodhandlers is more difficult than on larger vessels. The men live together in close association, often over a period of years. For this group the average time of submarine duty was 46 months.

There was, however, no evidence of dissemination (table 3), 9.6 percent of the men harbored *E. histolytica*. In estimating from the control study the number of infections in this group acquired previous to submarine duty, an almost identical percent of 9.0 was obtained.

The helminth indices were low. Hookworm, which was quite prevalent in the other groups, was found in but 0.8 percent.

Asiatic group.—In men returning from duty in the Orient, 26.1 percent of the men were found to be infected with the amebic dysentery protozoan as shown in table 3, 10.9 percent of the men harbored helminths.

In both instances, it is evident that new infections had been acquired, the indices being so high that comparisons with the control group are not required.

TABLE 3
Incidence of intestinal parasites, U. S. Navy

	Submarine group *	Asiatic group †	Summary of Tables 1, 2, & 3	
			Number	Percent
Number of men examined.....	251	92	1,021	-----
Percentage of protozoal infections.....	51.8	54.4	480	47.0
Percentage of helminth infections.....	1.6	10.9	57	5.6
<i>E. histolytica</i>	9.6	26.1	118	11.6
<i>E. coli</i>	23.5	28.3	255	25.0
<i>E. nana</i>	24.3	28.3	232	22.7
<i>I. bütschlii</i>	4.8	4.3	43	4.1
<i>D. fragilis</i>	6.4	2.2	66	6.5
<i>G. lamblia</i>	6.8	14.1	73	7.2
<i>T. hominis</i>.....	.8	3.3	13	1.3
<i>C. mesnii</i>	1.2	2.2	15	1.5
<i>N. americanus</i>.....	.8	3.3	35	3.4
<i>T. trichiura</i>	-----	2.2	9	.9
<i>T. hymenolepis nana</i>	-----	-----	4	.4
<i>A. lumbricoides</i>.....	.4	4.4	5	.5
<i>S. stercoralis</i>.....	.8	1.1	5	.5

* Average length of duty in submarine service: 46 months.

† Average length of duty in Asiatic service: 31 months.

The average length of service in the Asiatics for these men had been 31 months. They had been stationed in Peiping, Shanghai, in the Philippine Islands, and aboard ships of the Asiatic fleet.

General incidence of infection for all groups.—Including all groups, the results of which are summarized in table 3, a total of 1,021 Navy men were examined. Almost one-half of these harbored one or more protozoal species. The rate for helminths was 5.6 percent, of which *N. americanus* was by far the most prevalent. *E. histolytica* was found in 11.6 percent. This amebiasis rate is a fairly representative figure for the general prevalence of this infection in the Navy. The various groups represent a fair sampling of the service population. The high percentage of infections encountered in the Asiatic groups is included, for this unit comprised about one-tenth of the total number examined, which is a like proportion of the total naval forces actually stationed in the Orient.

DISCUSSION

Prevalence of amebiasis in the Navy compared to civilian population.—Although one would expect amebiasis to be more prevalent in a migrating population such as the Navy, remarkably enough, the naval incidence of 11.6 percent amebic infections is no greater than that reported for the civilian population of the United States. Craig,⁸ in summarizing the reports on some 50,000 examinations conducted in various parts of the country by different workers, obtained an average incidence of 11.6 percent. For an age group similar to that of the Navy, Reed and Johnstone⁹ report 9.2 percent infection in 1,000 prisoners in a California institution. Wenrich and his associates,¹⁰ doing single examinations upon college students, found 4.1 percent amebiasis, but concluded that the true incidence was probably closer to 10 percent.

Source of amebic infections encountered in the service.—From the epidemiological data obtained in the naval survey, it is apparent that a large majority of the carriers have become infected prior to enlistment in the Navy and incident to residence in the United States. This was well shown by the high prevalence of amebiasis found in recruits from all parts of the country. On the other hand, duty in the American tropics did not result in any appreciable number of men becoming infected, this in spite of the common belief that residence or travel in such endemic regions is dangerous. Furthermore, though without doubt there were many infected carriers serving food to the sailors both ashore and aboard ship, transmission by foodhandlers was not evident. One wonders if the greatly stressed importance of this means of dissemination, as noted by Craig,¹¹ Reed,¹² and many other authorities has not received undue emphasis.

⁸ Craig, C. F.: Amebiasis and amebic dysentery. Charles C. Thomas, Baltimore, Md. Page 45, 1934.

⁹ Reed, A. C., and Johnstone, H. G.: Amebiasis among one thousand prisoners. *Am. J. Trop. Med.*, **14**: 181-189, March 1934.

¹⁰ Wenrich, D. H., Stahler, R. M., and Arnett, J. H.: The incidence of the disease-producing amoeba (*Endamoeba histolytica*) in 1,000 college freshmen and its significance. *Science*, **79**: 143-144, February 1934.

¹¹ Craig, C. F.: The epidemiology of amebiasis. *J. A. M. A.*, **103**: 1061-1063, October 1934.

¹² Reed, A. C.: Clinical amebiasis and newer methods of treatment. *Northwest Med.*, **30**: 325, December 1931.

The fact that the rate of histolytica infection in men from the Asiatics was trebled leaves no question of the hazard of acquiring amebiasis in that part of the world. It is evident that the men experience very different conditions of exposure in the Orient. It is quite probable that the widespread use of night soil in the growth of garden foodstuffs may be of importance, though the general lack of proper sewage disposal in some parts suggests the possibility of many other means of fecal contamination of food or drink.

One may conclude, with the exception of the difficult problem encountered in the Orient, that sanitary regulations in the Navy at present are on the whole effective safeguards in the control of the transmission of amebic infections. However, the fact that there are estimated to be some 15,000 carriers in the Navy clearly points to the necessity for rigorous sanitary maintenance. Unfortunately, it is not feasible to detect and treat this large number of cases by any practical methods available at the present time.

This conclusion also holds true for the detection of carriers upon discharge to civilian life. But, aside from this, when one considers the millions of carriers already existent in the civilian population of the United States, the number of carriers among discharged sailors are by comparison an unimportant source of the spread of the amebic infections.

Morbidity from amebiasis in the Navy.—The fact that amebic dysentery is on the increase in the Navy indicates that all aspects of the problem are deserving of careful consideration. Stuart¹³ in 1928 pointed out that the disease rate for the Navy had increased from 27/100,000 in 1917 to 34/100,000 in 1926, or an average rate for the 10 years of 25/100,000. Statistics for 1936,¹⁴ 10 years later, indicate a further rise in the occurrence of dysentery, the 5-year median rate amounting to 55/100,000. However, it seems quite possible that this may be due to the recognition of larger numbers of cases as a result of modern advances in the knowledge of dysentery.

It is interesting to note, however, that on the basis of this 5-year rate for dysentery and 11.6 percent incidence of carriers, only 4.6 cases of clinical dysentery occur in the Navy for every 1,000 carriers of *E. histolytica*. This remarkable ratio is one of the major unexplained problems in amebiasis. No one has been able to demonstrate the mechanism which precipitates the dysenteric syndrome.

While these relationships between carriers and those ill from this protozoan are highly significant, they do not include morbidity which many observers are emphasizing as being due to the presence of the organism and yet not commonly recognized. It is becoming

¹³ Stuart, M. A.: General considerations on amoebic dysentery and *Endamoeba* carriers. U. S. Nav. Med. Bul., 26: 411-438, April 1928.

¹⁴ Statistics of Diseases and Injuries in the United States Navy. For the calendar year 1936. U. S. Government Printing Office, Washington, 1938.

more evident that illness grading from mild, unimportant symptomatology to advanced and severe disease may result from this parasite and be unaccompanied by dysentery. Indeed, Craig¹⁵ states that no less than 65 percent of all carriers have definite symptoms referable to *E. histolytica*, and has emphasized the frequency with which such cases are overlooked when search is not made for the causative ameba. One need only to study the diagnostic difficulties experienced during the Chicago outbreak of dysentery in 1933¹⁶ to be convinced of the protean nature of the clinical manifestations of this parasite, and the ease with which the proper diagnosis may be missed.

Intestinal parasites other than E. histolytica.—Of the helminths, it appears that *A. lumbricoides* and other intestinal worms are acquired incident to duty in the Orient. The findings concerning protozoa other than *E. histolytica* coincide, in general, with those of other workers. They may, however, serve as a guide for the frequency with which intestinal parasites should be encountered in naval laboratories doing this type of work.

The incidence of *Dientamoeba fragilis* reported in this study is perhaps worthy of particular note. Until recently this protozoan was considered relatively rare; yet in the Norfolk southern group it was encountered in 17.1 percent of the men, and in recruits from other parts of the country in 10.4 percent. The average incidence in all groups was 6.5 percent. This high prevalence is of interest in that *D. fragilis* has been suggested by Hakansson¹⁷ and others, as a possible human pathogen.

SUMMARY

1. The examination of 1,021 men of the Navy revealed 11.6 percent infections with *Endamoeba histolytica*. The major proportion of these infections were incident to residence in the United States, prior to naval service, as indicated by 14.7 percent infections in recruits from the southeastern part of the country, and 7.8 percent in those from other parts of the United States.

2. For men on duty in the American tropics, a highly endemic region for dysentery, the rate was 9.5 percent. On the other hand, for men returning from the Asiatics 26.1 percent infections were found.

3. There was no evidence of transmission of the dysentery organism aboard naval vessels. In submarines selected as a type of ship in which dissemination was most likely to occur, the rate was but 9.6 percent.

¹⁵ Craig, C. F.: Amebiasis and amebic dysentery. Charles C. Thomas, Baltimore, Md. Page 122, 1934.

¹⁶ Epidemic amebic dysentery. National Institute of Health. Bul. No. 266: 93-130. U. S. Treasury Department, Washington, D. C., 1935.

¹⁷ Hakansson, E. G.: *Dientamoeba fragilis*, a cause of illness. Am. J. Trop. Med., 16: 175-184, March 1936.

4. The numbers of infected men returning to civilian life upon discharge from the naval service cannot be considered an important source of infection to the civilian population of the United States.

5. The increase in clinical amebic dysentery in the Navy during the last 20 years indicates the necessity of maintaining rigorous sanitary control. For every 1,000 carriers of the dysentery organism in the Navy, there are but 4.6 cases of dysentery, but it is stressed that the actual morbidity from *E. histolytica* is probably much greater than these statistics would indicate.

6. Hookworm occurred in 14 percent of southern recruits and its incidence remained fairly high in other groups. All of these infections appear to have been acquired prior to naval service. *Ascaris* and other helminths were acquired during service in the Orient. The incidence of 17.1 percent of *Dientamoeba fragilis* found in one group, is the highest which has been reported in the United States.