Trichiniasis in the U.S. Population, 1966-70

PREVALENCE

EPIDEMOLOGIC FACTORS

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PREVALENCE

THE WORLDWIDE distribution of helminthic infections was assayed in 1947 by Stoll (*1*). He estimated that 20 million people in the United States were infected with *Trichinella spiralis*—three times as many as in the remainder of the world. This estimate was both alarming and surprising, especially in light of the relatively advanced state of U.S. public health and technology. However, no specific program has been activated to control the disease.

Fortunately, since 1947, advances have been made in swine management, control of diseases among swine, and pork processing and storage. Although all these advances were not trichina oriented, they have notably reduced the incidence of trichiniasis in swine.

Since pork is the primary vehicle for human infection, nationwide studies were initiated in 1966 at the Veterinary Medical Research Institute (VMRI), Iowa State University, Ames, to determine possible changes in the prevalence of trichiniasis in both swine and man. The completed swine study has been reported (*2*). A preliminary report on the studies of human beings, based on examination of 5,000 diaphragms, was published in 1968 (*3*). The completed study on man extended from February 1966 through December 1970 and included 8,071 human diaphragms. In this paper, we present a report on the prevalence of *T. spiralis* infections, general findings of the study, and the epidemiologic characteristics associated with the prevalence of the disease.

Review of Literature

Since the U. S. trichiniasis problem was recently reviewed in detail (*4a*), we present only a brief summary of it. The National Institutes of Health (NIH) carried out a similar study in 1936-41 to determine the prevalence of trichiniasis in man (*5, 6*). The diaphragm samples were obtained from cadavers in hospitals in 37 States and the District of Columbia. An overall prevalence of 16.1 percent was obtained from 5,313 diaphragms examined. The prevalence by geographic area varied from 18.5 percent in the Pacific States to 10 percent in the Mountain States.

Other significant epidemiologic findings included (*a*) 45 percent of the positive diaphragms contained live trichinae, indicating "recent" infections, (*b*) infection rates were relatively high for all age groups, 18.3 percent for persons 45 years of age or older and 12.6 percent for those under 45 years, and (c) the infection rates for persons of German extraction (28.3 percent) and Italian extraction (29.7 percent) were nearly double the overall national rate, whereas the 2.1 percent rate for the Jewish population sample reflected that people's general abstinence from products containing pork.

In addition to the NIH study, numerous other local studies were carried out during the same period (*4a*). Although the prevalence varied from 36 percent to 3 percent, the overall rate of nearly 16 percent confirmed the findings of the NIH study.

Limited studies of trichiniasis in man were carried out during the 1950s and early 1960s. Reports from the eastern half of the United

States indicated a prevalence of 3.4 percent (*4a*), thus suggesting a reduction of more than 75 percent in two decades. These findings agree with our preliminary results (*3*), in which 4.2 percent of 5,000 diaphragms were found to contain trichinae. A reduction in reported clinical cases in man (*7*) parallels the reduction in prevalence. A yearly average of 404.5 cases was reported for 1947–50, 339.2 for 1951–55, 200.6 for 1956–60, 221 for 1961–65, and only 113.4 for 1966–70.

There also was a marked reduction of the infection rate in swine. In farm-raised swine, which comprise about 98.5 percent of those marketed, the prevalence of trichiniasis decreased from 0.95 percent in the 1930s to 0.63 percent in 1948–52 (*8*). Recent studies revealed a prevalence rate of about 0.125 percent (*2,9*).

The prevalence of trichiniasis in garbage-fed swine was 5.7 percent in the 1930s, 11.0 percent in 1950, and 2.2 percent in 1954-59 (*8*). The 1954–59 decrease in trichiniasis occurred after regulations requiring cooking of garbage were enacted as a result of numerous outbreaks of vesicular exanthema in swine. Through a hog cholera eradication program, started in the 1960s, the prevalence of trichiniasis has been further reduced to about 0.5 percent (*2, 10*).

Material and Methods

This study was carried out in cooperation with personnel of State and city health departments and the pathologists and associated personnel from selected hospitals who submitted diaphragm samples and related epidemiologic data.

Statistical design. The statistical design and the procedures for collecting samples have been described in detail (*3*). We present only a condensed version here.

Diaphragm samples were obtained from cadavers autopsied in general hospitals having residencies in pathology (*11*). Exceptions were made when embalming precluded cooperation of the hospitals. Veterans', children's, and other specialty hospitals were usually excluded to reduce age bias.

A tentative sample of 10,000 human diaphragms was allotted to the 50 States and the District of Columbia in proportion to the number of deaths occurring in each State in 1963. A sampling rate for each State was determined by dividing the tentative sample allocation by the number of autopsies performed in eligible hospitals within each State during 1963.

Within each State, one of every four eligible hospitals was selected at random for the study. The State sampling rate was increased proportionately by a factor equivalent to the total number of eligible hospitals in a State divided by the number of selected hospitals. This rate was then applied to the listed 1963 autopsies to determine the desired number of consecutive autopsies for each selected hospital within a State.

In States having no hospitals with residencies in pathology, the sample number for the State was determined by the percentage of total U.S. deaths which occurred within the State during 1963. The participating hospitals in these States were selected by their respective State departments of health. Using the allocation procedure described for individual hospitals randomly selected within States, the desired total national sample became 9,574 human diaphragms from 187 hospitals.

Collection and examination of samples. The cooperating pathologists were requested to collect a 50- to 100-gm portion of diaphragm from cadavers that were not embalmed. The diaphragm samples were then sent in individual plastic bags to the VMRI for examination. A small amount of boric acid powder was added to each bag to deter spoilage. The filled-in questionnaire which accompanied each sample contained pertinent epidemiologic information about the deceased.

Two methods of examination were used: the artificial digestion-Baermann technique and the trichinoscopic method (*3*). The methodology was similar to that used in the NIH 1936–41 studies, except that a 20-mesh Baermann screen was substituted for an 80-mesh screen. The larger sieve opening allowed passage of calcified cysts which had withstood digestion.

Statistical analysis. Data reported on the questionnaires and the results of the analyses of the diaphragm samples were processed by the statistical laboratory at Iowa State University. Tabulations showing the relationships between prevalence and various epidemiologic factors (such as area of residence, age, and national origin of the decedent) were prepared.

The prevalence in different subgroups of the sample, as defined by the epidemiologic factors investigated, were compared. Let

$d = p_1 - p_2$

where p_1 = prevalence in subgroup 1 and

Figure 1. Distribution of participating hospitals in the Veterinary Medical Research Institute study, 1966–70

p_2 = prevalence in subgroup 2.

Then a rough estimate of the standard deviation of d was obtained by

$$s_d = \sqrt{s^2_{p_1} + s^2_{p_2}}$$

$$= \sqrt{\frac{P_1 (1 - p_1)}{n_1} + \frac{p_2 (1 - p_2)}{n_2}}$$

where n_1 = number of diaphragms analyzed in group 1 and n_2 = number of diaphragms analyzed in group 2. Approximate 95 percent confidence limits for the mean d were determined by $d \pm 2s_d$. If this interval did not enclose zero, the difference in prevalence rates was considered significant at approximately the 95 percent confidence level.

Results

From February 1966 through December 1970, specimens from 8,071 human diaphragms, or 84.3 percent of the desired total of 9,574 samples, were examined for *T. spiralis*. The samples were obtained from 48 States (all but Nebraska and Wyoming) and the District of Columbia; 178 hospitals in 73 cities were represented (fig. 1). Of the participating hospitals, 104 submitted their assigned quotas of diaphragms: 30 other hospitals, 90–99 percent; 27 hospitals, 50–89 percent; while 17 hospitals provided less than 50 percent of their quotas.

Prevalence of infections. The results of the examinations are shown by region and State in table 1. Data from the 1936–41 NIH study (*5*) are included for comparison. Only 335 (4.2 percent) of the 8,071 diaphragms contained trichina larvae or cysts, or both. Infected diaphragm samples were obtained from 130 of the 178 hospitals in 42 States and the District of Columbia. The five States with a prevalence rate of more than 6 percent were Oregon, 8.3 percent; New Jersey, 7.7 percent; Maine, 6.9 percent; Washington, 6.1 percent; and Nevada, 20 percent. Since Nevada was represented by only five samples, its rate was subject to a large sampling error. Seven other States had prevalences of 5 to 5.9 percent. Only negative samples were submitted from Alaska, Louisiana, Mississippi, Montana, North Dakota, and Vermont, but small numbers of samples, especially from Alaska and Vermont, may have been a contributing factor.

The Pacific, Middle Atlantic, and New England

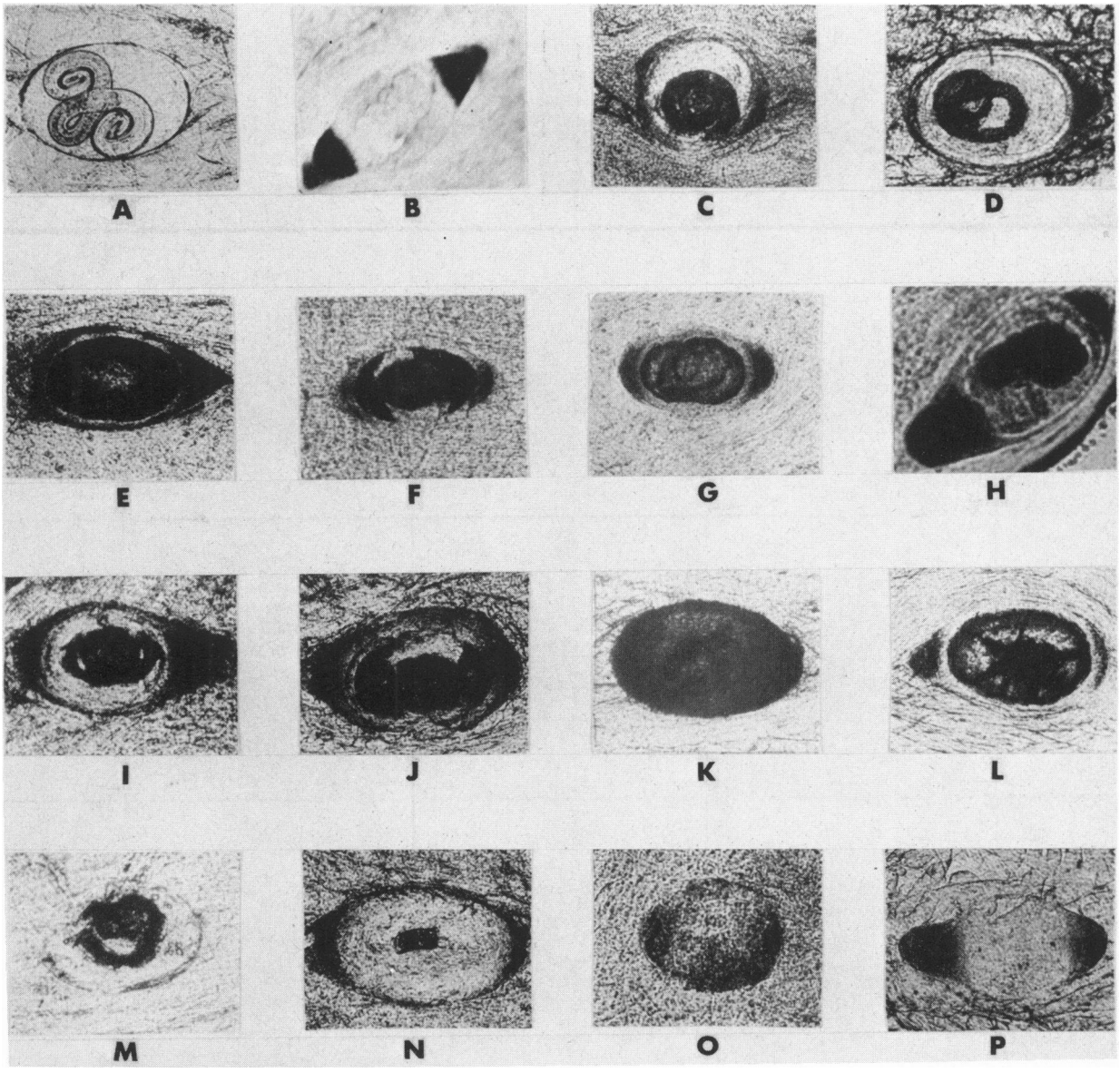
Table 1. Prevalence of *Trichinella spiralis* infections in the U.S. population, 1966–70 and 1936–41, by geographic region and State

Region and State	Veterinary Medical Research Institute study, 1966–70			National Institutes of Health study, 1936–41		
	Samples examined	Number positive	Percent positive	Samples examined	Number positive	Percent positive
New England	639	33	5.2	286	50	17.5
Maine	73	5	6.9	0	0	0
New Hampshire	37	2	5.4	118	18	15.3
Vermont	26	0	0	10	4	40.0
Massachusetts	301	15	5.0	130	21	16.2
Rhode Island	35	2	5.7	10	3	30.0
Connecticut	167	9	5.4	18	4	22.2
Middle Atlantic	1,626	89	5.5	809	104	12.9
New York (upstate)	485	24	5.0	456	41	9.0
New York City	362	22	6.1			
New Jersey	284	22	7.7	45	9	20.0
Pennsylvania	495	21	4.2	308	54	17.5
East North Central	1,642	63	3.8	355	63	17.7
Ohio	379	14	3.7	87	16	18.4
Indiana	231	6	2.6	52	13	25.0
Illinois	533	22	4.1	117	19	16.2
Michigan	343	14	4.1	77	10	13.0
Wisconsin	156	7	4.5	22	5	22.7
West North Central	523	17	3.3	198	35	17.7
Minnesota	136	3	2.2	50	9	18.0
Iowa	62	2	3.2	37	6	16.2
Missouri	179	7	3.9	60	11	18.3
North Dakota	31	0	0	0	0	0
South Dakota	25	1	4.0	1	1	100.0
Nebraska	0	0	0	39	7	18.0
Kansas	90	4	4.4	11	1	9.1
South Atlantic	1,421	45	3.2	3,028	493	16.3
Delaware	23	1	4.4	1	0	0
Maryland	184	4	2.2	387	86	22.2
District of Columbia	64	2	3.1	2,525	394	15.6
Virginia	88	2	2.4	33	5	15.2
West Virginia	37	1	2.7	1	0	0
North Carolina	212	8	3.8	18	3	16.6
South Carolina	81	4	4.9	15	1	6.7
Georgia	210	7	3.3	33	2	6.1
Florida	522	16	3.1	15	2	13.3
East South Central	703	22	3.1	85	15	17.6
Kentucky	252	14	5.6	0	0	0
Tennessee	192	4	2.1	41	8	19.5
Alabama	230	4	1.7	34	6	17.6
Mississippi	29	0	0	10	1	10.0
West South Central	431	13	3.0	110	20	18.2
Arkansas	64	2	3.1	2	0	0
Louisiana	74	0	0	0	0	0
Oklahoma	180	8	4.4	87	17	19.6
Texas	113	3	2.7	21	3	14.3
Mountain	309	10	3.2	80	8	10.0
Montana	9	0	0	0	0	0
Idaho	32	1	3.1	0	0	0
Wyoming	0	0	0	2	0	0
Colorado	97	4	4.1	30	3	10.0
New Mexico	42	1	2.4	1	0	0
Arizona	69	1	1.5	43	3	7.0
Utah	55	2	3.6	0	0	0
Nevada	5	1	20.0	4	2	50.0
Pacific	777	43	5.5	362	67	18.5
Washington	164	10	6.1	200	40	20.0
Oregon	60	5	8.3	33	4	12.1
California	519	27	5.2	129	23	17.8
Alaska	6	0	0	0	0	0
Hawaii	28	1	3.6	0	0	0
United States	8,071	335	4.2	5,313	855	16.1

Table 2. Condition of the trichinae and efficacy of methods of detection

Condition of trichinae	Positive samples		Digestion only		Trichinoscope only		Both methods	
	Number	Percent	Number	Percent	Number	Percent	Number	Percent
Live	42	12.5	35	83.3	1	2.4	6	14.3
Dead	288	86.0	97	33.7	65	22.6	126	43.9
Mixed	5	1.5	0	0	0	0	5	83.3
Total	335	100.0	132	39.4	66	19.7	137	40.9

Figure 2. Representative trichina cysts (B-P) observed in human diaphragms; noncalcified cyst with live trichina (A) from rat diaphragm included for comparison (magnified approximately 70 x)



regions had prevalences of more than 5 percent. Prevalences from the other six geographic regions ranged from 3.8 percent in the East North Central States to 3 percent in the East South Central States. The prevalences for the United States and all the regions but the Mountain States were significantly lower at the 95 percent confidence level than corresponding results in the NIH study three decades previously.

Condition of trichinae. The samples with trichinae were classified according to whether they contained living larvae, dead larvae, or both (table 2). Dead larvae were the predominant form occurring in 288 (86 percent) of the positive samples. All but 10 of the 288 samples exhibited some degree of calcification. Forty-two (12.5 percent) of the infected diaphragms contained only living trichinae; five (1.5 percent) contained a mixture of live and dead trichinae.

Representative cysts observed in trichinoscopic examination are shown in figure 2. A noncalcified cyst with a live trichina (A) from the diaphragm of a rat is shown for comparison, since none of this type were observed in several thousand cysts viewed. Only one cyst (B), with bipolar calcification, had an apparently live trichina. The extent and distribution of the calcification within the cysts varied, ranging from monopolar calcification (C-E) through bipolar (B, F-J) to complete or nearly complete (K) calcification. The larvae in calcified cysts usually appeared desiccated or calcified. A "star" effect (L) was often observed. Calcified trichinae were sometimes found in noncalcified cysts (M). Cysts with fragments of trichinae (N) or devoid of trichinae (O, P) were not uncommon. Partially resorbed cysts devoid of trichinae were noted occasionally.

The cyst size varied markedly, as shown in figure 2. The mean length of typical cysts from 10 diaphragms was 378 microns (range, 314–457) and the mean width 258 microns (range, 214–286). This mean size is similar to the average size of 400 x 260 microns reported by Gould (*4b*).

Efficacy of detection methods. Artificial digestion was the more efficient of the two diagnostic methods used (table 2). About 40 percent of the infections were detectable by either method. Another 40 percent were detected only by the digestive method, whereas 20 percent were revealed only by trichinoscopic examination. Thus 80 percent of the infections were detected by digestion and 60 percent by trichinoscopic examination. These results indicate the desirability of using both methods in surveys. Use of the digestion method resulted in detection of nearly 98 percent of the infections found with live trichinae only and 77.6 percent with dead trichinae only. In contrast, the trichinoscopic method resulted in detection of only 16.7 percent of the samples with live trichinae and 66.5 percent of those with dead trichinae. All mixed infections were detected by both methods.

The use of 20-mesh Baermann screen increased the efficacy of the digestion procedure. Since calcified cysts normally will not pass through an 80-mesh screen such as used in the NIH study (*5*), the detection of 97 infections with dead larvae only (nearly all calcified cysts) was attributed primarily to the use of the screen with larger openings. We noted that when samples were positive by both methods, the yield per gram for digestion was markedly less than that obtained by trichinoscopic examination. The difference indicated that many calcified cysts were destroyed by the digestive process.

Effect of size of sample. Although 50- to 100-gram samples were requested, 5,857 (71.3 percent) of the 8,071 samples digested weighed less than 50 grams. An analysis of the results obtained by digestion indicated a three-layer weight effect. Overall, 3.8 percent of the samples were positive by digestion. Samples of 10 grams or less yielded a prevalence of 1.3 percent; those in the 11- to 70-gram range, a prevalence of 3.5 percent; and those in the 71- to 100-gram range, a positive rate of 4.6 percent. Thus, routine use of a 71- to 100-gram sample for digestion might have increased the observed prevalence approximately 1 percent.

Intensity of infection. Relatively light infections predominated, with 127 (37.9 percent) of

Table 3. Intensity of infection related to condition of trichinae

Larvae per gram	Positive samples		Number of samples with larvae		
	Number	Percent	Live	Dead	Mixed
Less than 1....	127	37.9	32	95	0
1–10.....	174	51.9	10	161	3
11–50.....	27	8.1	0	25	2
51–100.....	4	1.2	0	4	0
101–500.....	3	0.9	0	3	0
Total....	335	100.0	42	288	5

Table 4. Prevalence for *Trichinella spiralis* in the 1966–70 Veterinary Medical Research Institute study and in the 1936–41 National Institutes of Health study, by age groups

Age group (years)	VMRI study 1966–70			Percent of samples positive in NIH study 1936–41
	Number examined	Number positive	Percent positive	
44 and under	1,312	24	1.8	12.6
1–4	58	0	0	1.2
5–14	125	1	.8	9.4
15–24	272	6	2.2	8.8
25–34	285	2	.7	11.3
35–44	572	15	2.6	14.9
45 and over	6,208	300	4.8	18.3
45–54	1,099	33	3.0	18.1
55–64	1,722	66	3.8	18.0
65–74	1,825	89	4.9	19.1
75–84	1,246	90	7.2	
85 and over	316	22	7.0	[1]17.5
Unknown	551	11	2.0	9.5
Total	8,071	335	4.2	16.1

[1] 17.5 represents combined 75–84 and 85 and over age groups in NIH study.

the trichinous diaphragms containing less than one trichina per gram. Another 174 (51.9 percent) contained only 1 to 10 per gram (table 3). Only seven diaphragms contained 50 or more trichinae per gram, a level Wright and co-workers (5) considered capable of producing definite symptoms of severe illness in man. The heavily infected diaphragms were obtained from decedents 56 years or older; all cysts were calcified. These findings suggested that those were "older" infections of several decades duration related to a higher level of swine involvement early in life. Three diaphragms had counts of 139, 106, and 104 trichinae per gram.

The positive samples containing living trichinae only were generally of light intensity, with 32 of the 42 diaphragms in this category containing less than one trichina per gram. The maximum larval count for positive samples with live trichinae was nine per gram. The numbers of live trichinae in each of the samples with mixed infections were also all less than 10 per gram.

Prevalence by age. Table 4 shows the prevalence rates by age in this study and in the earlier NIH study. The prevalence rates generally increased with age, reflecting increased risk of infection. In the VMRI study, only 24 (1.8 percent) of the 1,312 diaphragm samples from decedents 44 years and under contained trichinae. Fifteen of these were from persons 35 to 44 years of age. In contrast, the overall prevalence rate for the age group 45 years and older was 4.8 percent. This rate was significantly higher at the 95 percent confidence level than the prevalence for the under 45 group. The prevalences for both groups were significantly lower than corresponding rates reported in the NIH study.

Estimate of the problem in man. An age bias was inherent in this study, because the design was based on autopsies in the selected States and hospitals. Therefore, we attempted to obtain an improved estimate of the national prevalence (table 5).

The prevalence observed for each 10-year age grouping was multiplied by the actual population for this group. This procedure yielded the esti-

Table 5. Estimate of trichiniasis problem in U.S. population, 1940 vs. 1970

Item for comparison	NIH study, 1940	VMRI study, 1970	Percent change
U.S. population	132,122,000	203,166,000	+53.8
Prevalence at autopsy, percent	16.1	4.2	−73.9
Prevalence, weighted for age of population	12.0	2.2	−81.7
Human infections	15,853,000	4,432,000	−77.2
Percent of autopsies with live trichinae	7.2	.58	−91.9
Prevalence of live trichinae, weighted for age of population	7.3	.73	−90.0
Human infections with live trichinae	9,675,000	1,490,000	−84.7
Human infections per year[1]	967,500–1,935,000	149,000–298,000	.....

[1] Based on estimated 5- to 10-year lifespan of trichinae in muscle.

mate that approximately 4,400,000 or 2.2 percent of the U.S. population has detectable trichina infections compared with 15,900,000 people or 12 percent of the population three decades previously. Similar estimates of prevalences with live trichinae, indicative of "recent" infections, were that about 1,490,000 persons are currently infected with live trichinae compared with 9,675,000 during the NIH study.

Other studies in man. Three supplementary studies were carried out. Diaphragms from 4 stillborn infants and 72 children under 1 year of age were found to be negative. Trichinae were detected in 1 (3.4 percent) of 29 human diaphragms obtained from Puerto Rico. The positive diaphragm was from a 70-year-old woman.

After providing the desired quota for the primary study, a Buffalo, N.Y., hospital submitted matching tongue and diaphragm samples from 100 cadavers so that findings for the paired organs could be compared. Three diaphragms and two tongues, including two paired sets, contained trichinae. Since infections were relatively light, that is, a maximum of three trichinae per gram, the relative intensity of infections in the two organs could not be compared.

Discussion

Trichiniasis has decreased strikingly in the United States during the three-decade interval between the NIH study (1936–41) and the VMRI study (1966–70). The rate of prevalence derived from data obtained at autopsies declined during this period from 16.1 percent to 4.2 percent, a reduction approaching 75 percent. Thus the stigma of a trichiniasis rate three times that of the rest of the world probably no longer applies to the United States, but the U.S. current rate is still among the highest in the world (*4*).

Before we cite data that substantiate and emphasize this reduction, one observation should be emphasized. A comparison of prevalences by age groupings in the NIH and VMRI studies (table 4), with an allowance for a 30-year increase in age groups between studies, indicated that many older infections become undetectable with passage of time. Allowing for an estimated 1.5 percent increase in prevalence during the three decades, the data suggested that approximately 70 percent of the earlier infections were no longer detectable by the methods used in this study. This situation was undoubtedly brought about by death of the parasite and absorption of the cysts.

Partially absorbed cysts were evident in many samples examined with the trichinoscope. Thus, these findings would partly contradict the evidence of a real reduction in trichiniasis. However, although this clearing phenomenon is not peculiar to the three decades, it has undoubtedly been a factor since the beginning of the trichiniasis problem.

Other conditions, however, indicate definite reduction in prevalence. First, the weighting of prevalences by population within age groups (table 5) indicates the 1966–70 prevalence rate approximated 2.2 percent compared with a similarly adjusted 12 percent in the NIH study. Therefore, even with a population increase of more than 50 percent, the estimated number of people with detectable trichinae in their diaphragms had decreased 77 percent, from 15,900,000 in 1940 to 4,400,000 in 1970.

Second, this decrease is affirmed by the change in the relationship of prevalence to age. During the NIH study, 12.6 percent of the diaphragms examined from decedents under 45 years of age contained trichinae, as did 18.3 percent from cadavers of persons 45 years or older. The differential in prevalences between age groups was proportionately much larger in the VMRI study. Decedents 45 years and older during the 1966–70 study had a prevalence rate of 4.8 percent compared with only 1.8 percent for those under 45 years. Prevalences for children in the 5- to 14-year age group are representative of the attack rate over a limited period. In the NIH study, the prevalence for this age group was 9.4 percent; the 1966–70 prevalence rate is only 0.8 percent. This reduction is more than 90 percent.

The condition of the trichinae detected is another indicant of a declining problem. Living trichinae suggest recent infections, whereas cysts with partial or complete calcification can be related to older or remote infections.

The question arises as to what is the difference between recent and older infections in terms of time. Death of the parasite may occur any time after penetration of the musculature. The senior author (W.J.Z.) has observed phagocytosis of the parasites in swine musculature as early as 4 weeks postinfection. The trichinae in a pig with apparent clinical trichiniasis had almost completely cleared 4 months after infection. In other swine, trichinae survived up to 2 years with no noticeable change in cyst structure or viability.

Similar variability has been noted for human trichiniasis. Cysts usually begin to calcify 6 to 18 months after infection (*4b*). Investigators have suggested that trichinae may survive in calcified cysts for as long as 40 years (*12*). Our findings suggest that long survival is not common, because microscopic examination of about 10,000 calcified cysts detected by either the trichinoscopic or digestion method revealed only one calcified cyst with an apparently living larva. This finding suggests that calcification of cysts and death of trichinae usually are related.

Even following a single infection, marked variation in extent of calcification and its effect on larvae may be observed. Langerhans (*13*) reported 7 percent of the capsules unchanged in an infection believed to have occurred 31 years previously; 61 percent contained calcified and disintegrated larvae, and 32 percent were empty. Most of the stages shown in figure 2 were described.

In the NIH study, Wright and co-workers (*6*) found dead larvae in three of four positive samples from the 5- to 9-year age group, showing that death of the larvae can occur within a few years after infection. In another group of samples from cadavers from a mental hospital, they found live larvae in several cases where the patients had been hospitalized for more than 5 years. Since exposure to the parasite in the hospital was precluded or minimal, Wright and associates concluded that trichinae were capable of surviving 5 years or longer. In the VMRI study, the single infected host detected in the 5- to 14-year age category and four of the six infected hosts in the 15- to 24-year age group yielded living larvae.

Previously, Zimmermann had estimated an average 2- to 5-year lifespan for the parasite (*2*), realizing there could be many exceptions. Furthermore, in related data, prevalence rates for live trichinae were calculated on nonadjusted age data, giving an unreliable estimate of the extent of the problem. Based on findings in this and other studies, the 2- to 5-year estimate for lifespan of the parasite was probably low; an average of 5 to 10 years was more probable. Only 14 percent of the infected samples detected in the 1966–70 study contained living trichinae in contrast to 45 percent in the NIH study. Based on age-adjusted prevalences for living trichinae, approximately 1,490,000 persons (0.73 percent of the population) in the United States had live trichinae in their musculature during the 1966–70 study compared with 9,675,000 persons (7.3 percent of the population) three decades earlier. This comparison is probably the most valid indicator of a marked reduction in trichiniasis. The estimated lifespan of 5 to 10 years for the parasite indicates that each year about 150,000 to 300,000 persons are infected in contrast to 1 to 2 million three decades ago.

Another substantiating index of a decline is the decrease in reported clinical cases (*7*). The average yearly number of cases decreased from 404.5 during 1947–50 to only 113.4 during 1966–70. Mean numbers of reported deaths attributed to trichiniasis for the corresponding periods were 11.8 per year during 1947–50 and 1.4 for 1966–70. The average yearly number of reported cases seems inordinately small when compared with the estimated 150,000 to 300,000 infections occurring each year.

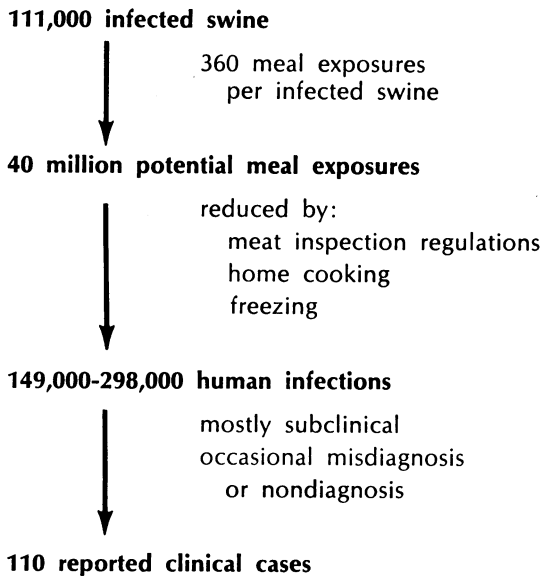
Several factors influenced this notable difference. Wright and co-workers (*5*) proposed guidelines that 11–50 larvae per gram may produce pronounced symptoms while 51–100 larvae per gram could produce severe illness. The maximum larval per gram count for diaphragms containing only live trichinae was nine; 37 of 48 diaphragms with live trichinae contained less than one live trichina per gram. Therefore, recent infections are light in intensity and clinical disease is relatively uncommon.

Thus, trichiniasis, like toxoplasmosis and certain other diseases, can be characterized by common infection and rare disease. The diverse clinical signs and symptomatology produced in clinical trichiniasis (*4c*) also contribute to lack of diagnosis or misdiagnosis of some infections. Therefore, the number of reported cases is not commensurate with the actual number of clinical cases that occur in any year.

Since parallel human and swine trichiniasis studies were carried out, we collated the data to obtain an estimate of the current U.S. trichiniasis picture (fig. 3). Based on current U.S. prevalence rates for swine, about 111,000 trichina-infected swine are marketed each year (*2*). A typical market-weight pig of 200 pounds has about 90 pounds of muscle. Based on an average pork serving of ¼ pound of muscle, each infected pig represents 360 potential meal exposures to man. Since a large amount of pork is mixed with meat from other animals in preparing sausage, 360 potential exposures are probably an underestimation. Therefore, the minimum is at least 40 million po-

tential meal exposures to trichiniasis each year in the United States. The numbers of viable trichinae are markedly reduced by destruction of trichinae in inspected ready-to-eat pork products, as required under meat inspection regulations, by home cooking, and by storage of pork in home freezers or commercial lockers.

Figure 3. Estimate of current yearly trichiniasis problem in the United States



Thus, an estimated 150,000 to 300,000 infections occur in man each year. Although most are nonclinical, many clinical cases of trichiniasis are not diagnosed, thus reducing the reported cases to approximately 100 per year. The 40 million potential meal exposures per year indicate that a typical U.S. citizen will risk infection once every 5 years or approximately 14 times in his lifespan. In contrast, Gould (*14*) estimated three potential exposures per person per year in 1945 or about 200 in a lifetime.

As we noted earlier, trichinae may die and the cysts may be absorbed, giving a misleading indication that a person has never been infected. Recognition of this is important in comparing studies with a span of time interposed. If a study similar to ours is carried out three decades from now, with the risk of exposure remaining constant, one can expect a marked reduction in prevalence due to an interaction of this clearing process and the death of other persons from the present era whose infective rate is primarily a reflection of the swine problem several decades ago. A more accurate picture of changes which may occur over a period of time may be obtained by using age-adjusted prevalences for living trichinae, since these prevalences involve infections contracted over a more limited span of time.

EPIDEMIOLOGIC FACTORS

THE QUESTION arises whether there are predisposing factors which may increase the probability of a human being acquiring trichiniasis. This section of the report presents results of an analysis

Table 6. Relationship of age to intensity and condition of trichinae, 1966–70

Age group (years)	Number samples	Number positive	Percent positive	Average intensity (trichinae per gm)	Condition			Percent positive with alive and mixed
					Alive	Dead	Mixed	
44 and under	1,312	24	1.8	2.4	9	14	1	0.8
1–4	58	0	0	0	0	0	0	0
5–14	125	1	.8	2.7	1	0	0	.8
15–24	272	6	2.2	.8	4	2	0	1.5
25–34	285	2	.7	7.6	0	1	1	.4
35–44	572	15	2.6	2.3	4	11	0	.7
45 and over	6,208	300	4.8	12.2	32	265	4	.6
45–54	1,099	33	3.0	12.5	7	26	0	.6
55–64	1,722	66	3.8	12.5	12	52	2	.8
65–74	1,825	89	4.9	12.9	8	80	1	.5
75–84	1,246	90	7.2	11.4	5	84	1	.4
85 and over	316	22	7.0	10.8	0	22	0	0
Unknown	551	11	2.0	2.5	1	10	0	.2
Total	8,071	335	4.2	11.2	42	288	5	0.6

of the data derived from examining the 8,071 diaphragm samples in an attempt to determine man-related factors which help perpetuate trichiniasis.

Material and Methods

The design of the epidemiologic study and methods for collection and examination of samples and analyses of data have been described earlier in this paper and in a previously published report (*3*).

We provided a questionnaire for each sample with a request that the pathologist provide available epidemiologic information about the decedent, including age, sex, national origin, religion, State of residence, rural or urban residence, major occupation, economic status, whether the patient was hospitalized, whether the patient had a chronic cardiac or neurological condition, and cause of death.

Results

Age. There was an increase in prevalence of trichiniasis with advancing age (table 6). Decedents under 45 years of age had a rate of 1.8 percent compared with 4.8 percent for those 45 years and older. The difference was significant at the 95 percent confidence level.

Intensity, as indicated by trichinae per gram, was age related. The average intensity for decedents under 45 years of age was 2.4 trichinae per gram; intensity for decedents 45 years and older was 12.2 per gram.

Little difference was found in the current attack rate between age groups. The prevalence of live trichinae ranged from 0 for the 1–4 and 85 and over age groups to 1.5 percent for the group 15–24 years old. In other groups, prevalence ranged from 0.4 to 0.8 percent.

National origin. Since the origins of the U.S. population are diverse, it is difficult to ascertain the national origin of most persons. However, an attempt was made to relate the probability of trichiniasis to national origin (table 7). Trichinae were isolated from 10.7 percent of 197 decedents identified as having Italian ancestry, from 9.2 percent of 500 decedents of German extraction,

Table 7. Relationship of trichiniasis to national origin

Country	Samples		
	Number examined	Number positive	Percent positive
Italy	197	21	10.7
Germany	500	46	9.2
Poland	141	8	5.7
Other:	3,549	126	3.6
Europe, Western	344	7	2.0
Europe, Eastern	57	4	7.0
Europe, Scandinavia	34	2	5.9
Asia	52	0	0
Africa	3	0	0
South America	4	0	0
Central America and West Indies	26	0	0
North America (excluding United States)	30	1	3.3
Not specified	2,999	112	3.7
Unknown	3,684	134	3.6

and from 5.7 percent of 141 decedents identified as of Polish descent. The rates for those of Italian and German extraction were significantly higher at the 95 percent confidence level than the rate for the population as a whole.

Although 3,549 diaphragm samples were identified as coming from persons whose lineage was not Italian, German, or Polish, only 555 were listed by the decedent's native country or area. Overall, 3.6 percent of the 3,549 in the "other" category contained trichinae. Included were infected samples from 3 of 89 decedents listed as Irish, 2 of 100 English, 2 of 26 French, 1 of 25 Russians, 2 of 5 Czechoslovakians, 1 of 12 Hungarians, 2 of 23 Scandinavians, and 1 of 22 Mexicans. National origin was "not listed" for 3,684 diaphragms; 3.6 percent of these were positive.

An inverse relationship was determined for prevalence and average intensity when associated with nationality (table 8). This difference undoubtedly reflected a higher propensity of Italians and Germans for eating sausage, with dilution of trichinae in sausage preparation being a primary factor. This propensity still persists, for the prevalence of live trichinae was 1 percent of the sample from Italian decedents and 1.8 percent of the sample from deceased Germans in contrast to about 0.5 percent for the combined "other" and "not listed" groups.

There was little difference in prevalence between broad age groupings for persons of Italian and German descent. The prevalences for the under-45 age groups were 11.1 percent for Italians and 7.8 percent for Germans, while those for the groups 45 years and older were 10.6 percent for Italians and 9.5 percent for Germans. All infected decedents of Polish descent were 45 years and older.

Sex and race. No differences between sexes were noted; 4.6 percent of the identified females and 4.1 percent of the males were infected (table 9). A prevalence of 4.5 percent was obtained for white decedents compared with 3.1 percent for the black sample. The difference was significant. The low sampling rates precluded analysis for Asian Americans and American Indians, but these prevalences are probably low.

Religion. The 5.4 percent prevalence obtained for deceased Catholics was significantly higher at the 95 percent confidence level than the prevalences for Protestant or other religious groups. National origin was not a factor because the prevalences were similar for Catholics and Protestants of either Italian or German extraction.

Many Seventh Day Adventists abstain from eating pork, as do most persons of Jewish or Islamic faiths. One of the 13 diaphragms from Seventh Day Adventists contained trichinae, but because the sample was small, the prevalence is subject to a large sampling error. The finding of trichinae in 1.6 percent of the Jewish decedents reflected this group's usual abstinence from pork. In the NIH study, the prevalence among Jewish decedents was only 2.1 percent. Thus, the marked reduction in prevalence among many other ethnic or religious groups was not reflected in the Jewish sample. All infected specimens in the NIH study were from decedents 55–84 years old.

Rural or urban residency. There was little difference in the prevalence of the disease between the urban and rural residents. A prevalence of 3.5 percent was ascertained for the rural sample, 4.3 percent for residents of towns with less than 10,000 population, which can be considered rural-related, and 4.3 percent for residents of cities with populations of 10,000 or more.

Occupation. Differences in prevalence of trichiniasis apparently were not related to occupation. Although there was a difference in prev-

Table 8. Relationship of national origin to intensity and condition of trichinae, 1966–70

National origin	Number samples	Number positive	Percent positive	Average intensity	Condition			Percent positive with alive and mixed
					Alive	Dead	Mixed	
Italian	197	21	10.7	3.6	2	19	0	1.0
German	500	46	9.2	4.9	8	37	1	1.8
Polish	141	8	5.7	6.3	0	8	0	0
Other	3,549	126	3.6	11.1	14	110	2	.45
Not listed	3,684	134	3.6	14.7	18	114	2	.54

Table 9. Epidemiologic characteristics of sample in VMRI study (excluding age, national origin, and medical)

Category	Number examined	Number positive	Percent positive
Sex:			
Male	4,546	185	4.1
Female	3,073	140	4.6
Unknown	452	10	2.2
Race:			
White	6,269	279	4.5
Negro	1,090	34	3.1
Asian American	45	0	0
American Indian	32	1	3.1
Unknown	635	21	3.3
Religion:			
Protestant	3,673	141	3.8
Catholic	1,601	86	5.4
Seventh Day Adventist	13	1	7.7
Jewish	247	4	1.6
Islam	1	0	0
Other	287	11	3.8
None	31	0	0
Unknown	2,218	92	4.1
Residence:			
Rural	934	33	3.5
10,000 or less	439	19	4.3
Urban, 10,000 or more	4,945	212	4.3
Unknown	1,753	71	4.1
Occupation:			
Agriculture	139	5	3.6
Restaurant	78	1	1.3
Housewife	2,134	106	5.0
Packinghouse	22	1	4.5
Professional	330	11	3.3
Managerial	271	13	4.8
Clerical or sales	395	15	3.8
Laborer	1,005	37	3.7
Student	202	4	2.0
Military	23	1	4.4
Retired	1,105	80	7.2
None or disabled	408	15	3.7
Preschool or unable to attend	83	0	0
Unknown	1,876	46	2.5
Economic status:			
High	488	18	3.7
Medium	3,225	130	4.0
Low	1,839	83	4.5
Unknown	2,519	104	4.1

alence between housewives 15 years and older (5 percent) and other women in the same age range (3.7 percent), the difference was not significant at the 95 percent confidence level. There was no difference between housewives and other women over 70 years old. Among the women of German descent, housewives 70 and under had a prevalence of 4.5 percent compared with 16.9 percent for those over 70. Housewives with Italian antecedents had a prevalence of 9.1 percent in the 70 years or under group and 14.8 for those over 70.

The 7.2 percent prevalence for retirees was related more to age than to specific occupations. The sample for packinghouse workers was too small to determine risk of this occupation. Other occupations which possibly could have had a relatively high risk of exposure, such as cooks and meat market employees, were not differentiated in the questionnaire.

Economic status. Although prevalence of trichiniasis is inversely related to economic status, the differences among three groups are minimal and not significant. The prevalences ranged from 3.7 percent for decedents who had high economic status to 4.5 percent for those whose incomes had been low. If only white decedents are considered, the range is somewhat greater but still not significant—3.8 percent for high economic status, 4.1 percent for medium, and 5.6 percent for low.

Hospitalization. The prevalence of 4.5 percent obtained among deceased hospitalized patients was significantly higher than the 2.6 percent obtained for those not hospitalized (table 10). The difference was probably age related since the age distribution in the latter sample represented a more extensive cross section of the population.

Chronic heart or neurological condition. Although the occasional migration of trichinae into heart muscle and nervous tissue possibly could produce a chronic heart or neurological condition, this was not confirmed since there were no significant differences in prevalence between categories (table 10).

Causes of death. Causes of death were obtained for most of the decedents whose samples were examined (table 10). Since multiple causes were often listed, the total number of causes exceeded the number of deaths. The basic causes were grouped into general system or disease-type categories. The highest rate was 5.7 percent for deaths from infectious diseases, but none were attributed to trichiniasis. Other high death rates were 5.2 percent for diseases of the genitourinary system and 5 percent for diseases of the circulatory system.

Deaths attributable to traumatic (accidental) causes had a prevalence of only 2.9 percent. This is comparable to the national age-adjusted prevalence of 2.2 percent and the prevalence of 2.6 percent among nonhospitalized persons.

Geographic residence. Although the U.S. population is highly mobile, an evaluation of re-

sults by regions (table 11) indicated a general uniformity of prevalence within regions. Prevalences of more than 5 percent were noted for the Middle Atlantic, Pacific, and New England areas; those of other regions ranged from 3 to 3.8 percent. A relationship between human prevalence, swine prevalence, and clinical attack rate within the geographic regions was indicated.

Heavy infections. Seven diaphragms contained more than 50 trichinae per gram. All trichinae were calcified, an indication of "older" infections.

Table 10. Medical characteristics of sample in VMRI study

Category	Number examined	Number positive	Percent positive
Hospitalized:			
Yes	6,471	293	4.5
No	646	17	2.6
Not indicated	954	25	2.6
Chronic condition:			
Heart	2,049	92	4.5
Neurological	537	21	3.9
Both	234	13	5.6
Neither	1,705	67	3.9
Unknown	3,546	141	4.0
Primary cause of death:			
Infectious disease	263	15	5.7
Neoplasm	1,836	72	3.9
Metabolic	240	9	3.6
Nervous and psychoses	602	21	3.5
Nervous and sense organs	80	2	2.5
Circulatory	3,572	178	5.0
Respiratory	1,505	63	4.2
Digestive	1,001	43	4.3
Urogenital	487	25	5.1
Reproductive	6	0	0
Skin and musculoskeletal	21	0	0
Congenital	20	0	0
Accidental (traumatic)	612	18	2.9

All of these diaphragms were from white decedents 56–88 years old. Five were from women, two from men. National origin of the decedents was listed as "other" for three, whereas four were in the "not listed" category. Four of the seven had been large-city dwellers, one was from a town with a population of less than 10,000, one was from a rural area, and the residence of one was unknown. Of the five women, four were housewives, and one's occupation was listed as sales or clerical. One man had been retired; the other's occupation was unknown. States of final residence were Massachusetts 2, New York 1, Florida 1, Missouri 1, California 1, and Washington 1.

Comparison of high- and low-prevalence areas. Comparisons of high and low prevalences were made for two sets of data: (*a*) Chicago and suburbs (2.7 percent) with the remainder of Illinois (7.5 percent) and (*b*) a high-prevalence hospital in New Jersey (15.3 percent) with Louisiana (0 percent).

The age distribution of the decedents was similar for the two Illinois samples, but the Louisiana sample ranged about 10 years younger than the New Jersey sample. There was little difference in other population characteristics.

Even with the similarity of characteristics, there were distinct differences in prevalence within the two groups compared. Among Illinois residents, the prevalence for downstate Illinois was generally from two to three times higher than for comparable groups from the Chicago metropolitan area.

Table 11. Comparison of trichiniasis in man and swine of the United States

Region	Prevalence in man, 1966–70 (percent)	Swine, 1961–70[1]				Clinical attack rate per 100,000 population 1960–70[2]
		Farm-raised		Garbage-fed		
		Number examined	Percent positive	Number examined	Percent positive	
New England	5.2	138	0	3,646	1.9	0.20
Middle Atlantic	5.5	1,263	.16	2,823	1.4	.16
East North Central	3.8	11,770	.28	267	1.1	.07
West North Central	3.3	14,720	.08	10	0	.12
South Atlantic	3.2	3,246	.03	741	.13	.03
East South Central	3.1	2,054	0	341	.29	.04
West South Central	3.0	2,260	.11	481	.42	.02
Mountain	3.2	1,688	.06	1,348	.22	.07
Pacific	5.5	933	.50	1,929	2.0	.09
Total	4.2	38,132	.13	11,586	1.5	.....
Estimated prevalence, 1970	.....	.....	.12	.....	.50	.....

[1]References 6, 7, 11. [2]Reference 8.

Although age, race, national descent, and having been a housewife appeared to contribute to the high prevalence among the sample from the New Jersey hospital, the sample from Louisiana with markedly similar characteristics yielded negative specimens.

Discussion

The common statement "This may be true, but——" may be appropriately applied to the evaluation of the epidemiologic data obtained in this study. Although 3 of the 12 characteristics studied, namely age, national origin, and geographic residence, would seem to be associated with the probability of having acquired trichiniasis, exceptions were common.

The effect of age is related to possible exposures to the parasite. A 60-year-old man presumably has had about twice as many meals of pork as a 30-year-old. Therefore, assuming a constant prevalence of trichiniasis in swine, the 60-year-old has had twice the number of potential exposures to the parasite. Fortunately, the prevalence in swine has decreased in recent decades; thus, the differences in exposure between age groups was even more pronounced. In 1945 the risk was estimated at three exposures per year (*14*); currently it is estimated at one in 5 years.

National origin also affects the probability of exposure to the parasite. The prevalence for decedents identified as being of Italian descent (10.7 percent) or of German ancestry (9.2 percent) was significantly higher than the 4.2 percent obtained for the population as a whole. The high prevalences for Italians and Germans were related to a propensity for eating pork, especially sausage. The sausage was often prepared from recipes originating from the ancestral countries. Quite often these family recipes involve incomplete processing, and therefore the product may be unsafe when consumed raw or partially cooked. Such problems usually are not apparent in most European countries because trichiniasis in swine is controlled by long-term use of compulsory microscopic examination of swine at slaughter. In contrast, the United States has never required that swine slaughtered for domestic consumption be inspected for trichiniasis. Thus, when families emigrated from Europe to the United States, they had a false sense of security.

Although ready-to-eat products prepared under Government inspection have been processed to kill trichinae, most sausage products involved in outbreaks have been prepared either by small markets not subject to regulations or at home. With the passage of the Wholesome Meat Act in 1967, most specialty producers of sausage have been brought under Federal or equivalent regulations.

Although age, national origin, and occasionally other factors may predispose a person to trichiniasis, geographic influences such as location, trichiniasis in swine related to swine management procedures, type of pork products available, and food habits in the area are even more important. Trichiniasis was centered in three regions, namely the Middle Atlantic, Pacific, and New England States. Twelve States, excluding Nevada with only five samples, had a prevalence of more than 5 percent. All but Kentucky are in these three regions. Five of the seven diaphragm samples containing more than 50 trichinae per gram originated from these three regions.

Swine are the primary reservoir of trichiniasis, and there is an apparent relationship between its prevalence in man and swine (table 11). In the early 1960s when Zimmermann began a series of collaborative studies with the U.S. Department of Agriculture on trichiniasis in swine, a major trichiniasis problem in swine existed in the three high-prevalence regions (*9*). Fortunately, a national hog cholera eradication program was initiated in 1962, with emphasis on cooking of garbage. The prevalence in garbage-fed swine decreased from 6.3 to 0.6 percent in Massachusetts, from 5.1 to 0.5 percent in New Jersey, and from 4.1 to 0 percent in California (*9, 10*).

Although these changes indicate a sharp decrease in the current problem in these regions, the prevalence rates obtained for human beings reflect the problem in swine over several decades.

Although swine are fed garbage in most States, studies have revealed only a low level of infection in swine of other areas where garbage feeding is allowed. Garbage-fed swine generally are slaughtered in the region where they are raised. Therefore, trichinous pork in garbage is continually recycled, and trichiniasis is perpetuated in a relatively limited area.

The Middle Atlantic and the New England regions have provided the primary ports of entry for immigrants from Europe. A large percentage of the immigrants, especially in the past, settled in nationally-oriented sectors of eastern cities where

Old World food customs have been maintained to a relatively high degree. In New Jersey, 20 percent of the Italian sample and 35.7 percent of the German sample were infected. Twelve of the 22 infected samples from Italian decedents came from the Middle Atlantic region, as did 22 of the 46 positive samples from German decedents; these data illustrate the problem of concentration of persons of national origin.

The bear is becoming more apparent as a source of human trichiniasis (*7, 15*). In 1968, 8 of 84 cases in man were attributed to ingestion of trichinous bear meat; in 1970, 13 of 109 cases were traced to bear meat; and in 1971, at least 11 of 101 cases resulted from eating bear meat. These cases were geographically related to the northern and western United States, with Alaska, California, and Idaho leading in human involvement.

The risk of infection for any person in the United States is now much less than for persons of comparable epidemiologic characteristics three decades ago. An estimated 1 to 2 million persons became infected with the parasite in 1940 in contrast to 150,000–300,000 in 1970. This decrease in human involvement is the result of the interaction of several factors, primarily the decline in the prevalence of the parasite in swine.

Nationally, the prevalence decreased from nearly 1 percent in farm-raised swine in the 1930s and 11 percent in garbage-fed swine during 1950 (*8*) to currently only 0.125 percent in farm-raised swine and 0.50 percent in garbage-fed swine (*2*). This decrease occurred without a specific trichina control or eradication program. Improvement in swine management and feeding programs is probably the primary factor. Nearly all swine are on intensive feeding programs centered on the feeding of grain, whereas table scraps, raw garbage, and raw offal formerly were fed to a large number of swine throughout the United States. There has been a 60 percent reduction in the number of swine fed commercial garbage since 1955, including a 92 percent reduction in the number of swine fed raw garbage. The reduction in garbage-fed swine is related to the development of swine-disease eradication programs for vesicular exanthema during the 1950s and hog cholera during the 1960s.

Improvements in the processing and storage of pork also have contributed to the decline of trichiniasis in man. The Wholesome Meat Act undoubtedly has had an impact on the problem because uninspected meat processors were eliminated. Home processing of pork products now is minimal. The relative abundance of home freezers and commercial lockers also has produced inroads on the problem. The destruction of trichinae by cooking, freezing, or adequate curing not only directly reduces the human health hazard but also reduces viable trichinae available in garbage.

Despite evidence of decreased prevalence of trichiniasis, the prevalence in farm-raised swine has been relatively stable during the period 1961–70. In fact, the prevalence in 1970 was the highest of the 10-year period (*11*). Similarly, the prevalence in garbage-fed swine has been steady after the initial impact of the hog cholera eradication program.

These findings indicate that trichiniasis will not disappear without the implementation of a specific eradication program. To be effective, such a program must include (*a*) elimination of garbage feeding, (*b*) an education program for all swine producers, and (*c*) use of an effective diagnostic program for swine at slaughter.

Although cooking of garbage has made inroads on the prevalence of trichiniasis in garbage-fed swine, the current prevalence of 0.5 percent indicates that not all garbage is being cooked thoroughly before it is fed to swine. If garbage feeding is not eliminated, then additional emphasis must be placed on adequate cooking procedures.

The feeding of "unofficial" garbage, such as table scraps and wildlife carcasses, to farm-raised swine now constitutes a major portion of the problem. An intensive educational program citing the hazard of feeding such material to swine must be developed to reach all swine producers.

The use of a diagnostic procedure at the time of slaughter of swine, accompanied by followup epidemiologic tracebacks, would not only protect the public from trichiniasis but would speed up elimination of the disease. Such a program, now being considered by the U.S. Department of Agriculture, would eliminate trichinous pork as a health hazard in the United States.

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ZIMMERMANN, W. J. (Iowa State University of Science and Technology, Ames), STEELE, J. H., and KAGAN, I. G.: ***Trichiniasis in the U.S. population, 1966–70. Prevalence and epidemiologic factors. Health Services Reports, Vol. 88, August–September 1973, pp. 606–623.***

A statistically designed study was carried out from February 1966 through December 1970 to determine the prevalence of *Trichinella spiralis* infections in the U.S. population. The study included the examination of 8,071 human diaphragms from 48 States and the District of Columbia. The samples were obtained from cadavers from 178 hospitals in 73 cities.

Trichina larvae or cysts were found in 335 (4.2 percent) of the diaphragms examined. The infected diaphragms came from 42 States and the District of Columbia. States with high prevalences were Oregon, 8.3 percent; New Jersey, 7.7 percent; Maine, 6.9 percent; and Washington, 6.1 percent.

Weighting of the observed prevalences for the population within age groups indicates that approximately 2.2 percent of the current population has detectable trichina infections, and 0.73 percent is estimated to have live trichinae, indicating "recent" infections.

An age-related prevalence differential was noted, with a prevalence of 1.8 percent for decedents under 45 years old and of 4.8 percent for those 45 and older. Dead trichinae predominated; only 14 percent of the positive samples contained live trichinae. The infections were generally light; 127 of the positive diaphragms contained less than one trichina per gram. Only seven diaphragms contained more than 50 per gram; the maximum was 139.

Epidemiologic characteristics associated with the prevalence of trichiniasis in human beings include geographic residence, age, and national origin. The human problem as indicated by human prevalence, reported clinical cases, and swine prevalence is centered in three areas, namely the Middle Atlantic, Pacific, and New England regions. The prevalence in man was related to increased exposure with age and a decreasing prevalence in swine. The prevalence rates for decedents of Italian and German extraction were significantly higher than the rate for the population as a whole.

During recent decades, the risk of acquiring trichiniasis has decreased. Such factors as improved swine management, garbage cooking regulations, decreased uninspected processing, improved pork storage, and changing food habits have contributed to a lessening of the problem.