The results of screening programs for heart disease in elementary schools of two Colorado towns are presented and compared with other surveys. The significance of the findings is discussed, and the possibility of establishing more precisely the prevalence of different kinds of heart disease is indicated.

HEART DISEASE PREVALENCE IN SCHOOL CHILDREN IN TWO COLORADO COMMUNITIES

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THE FREQUENCIES of heart disease in children of school age are obtained by delineation of a school population at risk of disease. Examinations are performed upon either the whole population or a sample selected from it. Earlier surveys concentrated upon the entity, rheumatic heart disease, a sequela of acute rheumatic fever. This chronic, progressive, life-shortening condition was apparently more common and more severe in western Europe and North America during the early part of this century and the two previous centuries than it is today. Acute rheumatic fever seems to be declining noticeably in severity.[70] Rheumatic heart disease mortality rates also seem to have fallen over this same period of time.[65] It would be interesting to know whether rheumatic heart disease prevalence rates are lower, too. Unfortunately, direct numerical comparisons cannot be made freely because auscultatory diagnostic criteria have been significantly refined, especially during recent years.[72] Improved diagnosis was probably largely due to increasingly successful cardiac surgery, which demanded accurate preoperative diagnosis.

As rheumatic fever is becoming less severe, typical cases are fewer, and the diagnosis is probably more difficult in a larger proportion of cases now than in years past. All are familiar with the one-third to one-half of cases of chronic rheumatic heart disease (RHD) which have never experienced an attack of acute rheumatic fever. One may legitimately wonder whether such cases are actually caused by rheumatic fever (undiagnosed or subclinical) or whether a whole spectrum of inflammatory agents can cause endocarditis with valvular deformities. Silber has reported cases of acute and chronic myocarditis with heart murmurs simulating those of RHD, and it is his belief that the label of RHD is too loosely applied in the absence of a positive history of rheumatic stigmata.[73] Saphir reports the same phenomena.[75] Endocardial elastomyofibrosis occurs predominantly in young adults but has been reported in adolescents and could easily be misdiagnosed as RHD.[74] Brucellosis can cause chronic progressive aortic valvular stenosis, although this infection is thought to be rare in children.[69] Studies with experimental animals suggest that

other infectious agents causing chronic valvular heart disease in human beings remain to be discovered.[71]

In mass screening programs it has been customary to group all those children with the typical clinical findings of valvular heart disease into the category of rheumatic heart disease. This category is overly specific and should be replaced by the term "acquired valvular heart disease" (AVHD). RHD should be reserved for those persons with AVHD who are known to have had acute rheumatic fever. From this standpoint, measurement of AVHD prevalence should not be considered to reflect only the ravages of rheumatic fever but should be considered as the possible result of a variety of inflammatory agents, although the nonrheumatic cases are probably definitely in the minority.

Persons who have had rheumatic fever can be prevented from having recurrent episodes by careful maintenance of drug prophylaxis against repeated hemolytic streptococcal infections which will presumably arrest the progressive nature of RHD and thereby lengthen the lives of those afflicted.

Persons with congenital heart disease (CHD) have benefited greatly from the development of refined surgical and anesthesiological procedures. Disability may be corrected or prevented in the common types of CHD seen in school-age children. Atrial septal defects (probably the commonest lesion) have been readily and safely repaired for about ten years. Ventricular septal defect and isolated pulmonic stenosis entail slightly more surgical risk but are successfully handled in most major medical centers. Patent ductus arteriosus and coarctation of the aorta have been surgically corrected with a high degree of success for about 15-20 years. The foregoing five defects comprise about 90 per cent of CHD cases seen in elementary school children. In this age group, coarctation of the aorta, patent ductus arteriosus, and atrial septal defect should be repaired as soon as the diagnosis is made with certainty,[64] while other defects should be carefully observed in order to determine the optimum time for surgical repair. Corrective surgery in each individual case should occur in the period of time between the onset of symptomatology due to the heart defect and the development of irreversible pulmonary vascular changes, so that maximum benefit will be obtained and life will be prolonged.

Constructive preventive and therapeutic efforts must be based upon a knowledge of the extent of the problem in order to plan and act appropriately. Prevalence figures have been collected or estimated in a variety of ways by a variety of investigators. After methods have been scrutinized, not all estimates are equally reliable.

In the course of heart disease screening programs involving school children in two Colorado communities, prevalence figures were obtained and compared between the two communities and with previous investigations in this and other geographic areas. There is risk in the assumption of direct comparability of prevalence figures from one area to another unless one can account for the meaning of differences in climate, altitude, socioeconomic environment, and other factors whose influence is unknown. Comparisons from one period of time to another must take note of considerable differences in diagnostic criteria and the consistency of their application. However, such comparisons are valid to the extent that prevalence figures from various times and places each represent an estimate of the extent of a problem at a certain time and place. The findings in the two Colorado communities will be described, then compared with estimates gathered elsewhere by others.

Materials and Methods

At the time of study (1956-1958) Durango, Colo., had a population of about 9,000 within the city limits and about 12,000 in the immediate metropolitan area. The town is situated at an elevation of 6,500 feet above sea level in a mountainous area. The average annual rainfall was 17.76 inches.[3] A previous report[1] described 19 cases of organic heart disease found in 1,619 children screened over a two-school-year period. Subsequently an additional 572 children were screened by use of the same methods; they are included in the figures presented in the present paper.

In Grand Junction, Colo., the case-finding program was performed during a shorter period of time (February and March, 1958). This community had a population of about 22,000 within the city limits and about 35,000 in the immediate metropolitan area. Its elevation is 4,575 feet above sea level. The average annual rainfall was 9.06 inches.[3] There have been no additions to the previously reported[2] total of 41 cases of heart disease found in 6,311 children examined (95.6 per cent of the total population at risk).

In general, Grand Junction was probably a more prosperous community and had fewer transients than Durango, but these are only impressions which were not objectively measured. Grand Junction had one physician per 980 persons in the county, while Durango had one per 1,560 persons. If osteopaths were omitted from consideration, the physician-population ratio became 1/1,280 in Grand Junction and 1/1,670 in Durango.

Heart disease screening methods used in the two communities were identical. The majority of children screened in each community were subjected to single lead (V_3R) electrocardiograms and 70 mm chest x-rays as well as cardiac auscultation.[4,63] Many of the same screening physicians were used in both programs, and all used the auscultatory methods and standards utilized at the University of Colorado Medical Center. The services of most of the examining physicians were obtained from the Cardiovascular Section of the Department of Medicine with the generous permission of its chief, S. G. Blount, Jr.

Results

In Table 1 is seen a comparison of age and sex distributions of children screened in the two Colorado communities. The larger numbers in the younger age groups in Durango reflect the fact that the screening program had been a continuing one over a three-school-year period and screened only the new arrivals after the first year of operation. The differences between respective total and sex-specific mean ages of the two populations were not statistically significant. Differences between respective age distribution variances of males and totals (but not of females) were statistically significant at the 5 per cent level. However, the significance of these last differences is discounted by the fact that even greater differences exist between male and female age variabilities within each community.

Since sex-specific age distribution differences between the two communities are exceeded by differences between sexes within each community, comparisons between the two communities are not contraindicated on the basis of different age distributions in the two populations.

Table 2 shows the heart disease age distributions and age-specific prevalence rates in the two communities. Total CHD prevalence rates per 1,000 are 5.5 in Durango and 5.2 in Grand Junction. Total AVHD prevalence rates per 1,000 are 4.1 in Durango and 1.1 in Grand Junction. An additional case of heart

Table 1—Comparison of Age and Sex Distributions in Durango and Grand Junction Elementary School Children

Age	Durango			Grand Junction		
	Male	Female	Total	Male	Female	Total
5	9	12	21	33	35	68
6	309	268	577	442	428	870
7	226	208	434	498	491	989
8	147	171	318	517	539	1,056
9	176	145	321	526	478	1,004
10	125	114	239	543	510	1,053
11	103	92	195	489	481	970
12 or older	50	36	86	177	124	301
Total	1,145	1,046	2,191	3,225	3,086	6,311
Mean	8.06	8.01	8.04	8.72	8.64	8.68
Variance	3.4462	3.2467	3.3499	3.3427	3.2649	3.3162
Standard deviation	1.86	1.80	1.83	1.83	1.81	1.82

Table 2—Comparison of Age Distribution with Type of Heart Disease in Durango and Grand Junction

Age	Durango				Grand Junction			
			Total				Total	
	CHD	AVHD	No.	Rate/1,000	CHD	AVHD	No.	Rate/1,000
5	0	0	0	0.0	1	0	1	14.7
6	0	1	1	1.7	2	2	4	4.6
7	1	0	1	2.3	4	0	4	4.0
8	4	1	5	15.7	7	1	8	7.6
9	3	4	7	21.8	3	0	3	3.0
10	4	0	4	16.7	11	0	11	10.5
11	0	2	2	10.3	4	2	6	6.2
12 or more	0	1	1	11.6	1	2	3	10.0
Total	12	9	21	9.6	33	7	40	6.3

disease found in Grand Junction and not listed in Table 2 was that of a ten-year-old boy with chronic cor pulmonale secondary to chronic severe asthma. Differences in CHD and total heart disease prevalence rates between the two communities are not statistically significant but the difference in AVHD rates is significant ($0.03<p<0.04$). The reason for the lower AVHD prevalence rate in Grand Junction may be related to the greater density of physicians and the impression of greater economic prosperity in Grand Junction than in Durango.

Table 3 presents age and sex distributions and prevalence rates of innocent heart murmurs in all children without

heart disease who have been examined in Durango. The same information from Grand Junction is presented in Table 4.

For analysis, the arcsin square-root-of-percentage transformation[5] was applied to the percentages listed in the bodies of Tables 3 and 4.

An analysis of variance technic used on the transformed data showed that, when age and community are accounted for, there is a significant difference (at the 5 per cent level) in per cent of innocent heart murmurs between the two sexes. That this sex difference differs significantly between the two communities detracts from its significance. The differences in occurrence of innocent heart murmurs between the two communities (independent of sex effects) and among the various age groups are not significant at the 5 per cent level.

Of previous surveys of heart disease

Table 3—Age- and Sex-Specific Rates of Occurrence of Innocent Heart Murmurs in Children without Evidence of Heart Disease in Durango, 1956-1958

Age in Years	Males			Females		
	Total without Heart Disease	Murmurs		Total without Heart Disease	Murmurs	
		No.	Per cent		No.	Per cent
6	317	115	36.3	280	71	25.4
7	226	73	32.2	207	49	23.7
8	147	64	43.5	166	35	21.1
9	171	68	39.8	143	48	33.6
10	123	45	36.6	112	26	23.2
11	103	34	33.0	90	26	28.9
12 or more	49	14	28.6	36	9	25.0
Total	1,136	413	36.4	1,034	264	25.5

Table 4—Age- and Sex-Specific Rates of Occurrence of Innocent Heart Murmurs in Children without Evidence of Heart Disease in Grand Junction, 1958

Age in Years	Males			Females		
	Total without Heart Disease	Murmurs		Total without Heart Disease	Murmurs	
		No.	Per cent		No.	Per cent
5	33	20	60.6	34	11	32.4
6	439	157	35.8	427	137	32.1
7	496	186	37.5	489	149	30.5
8	514	169	32.9	534	153	28.7
9	525	163	31.0	476	120	25.2
10	532	178	33.5	509	189	37.1
11	488	153	31.4	476	169	35.5
12 or more	176	61	34.7	122	53	43.4
Total	3,203	1,087	33.9	3,067	981	32.0

Table 5—Comparison of Heart Disease Surveys in Colorado School Children

Location	Date	Population Examined	Age Range	Heart Disease Rates per 1,000			Per cent of Normals with Innocent Heart Murmurs	References
				CHD	AVHD	Both		
Denver	1944-45	1,845 girls	12-17	2.7	16.3	19.0	?*	7
Denver	1944-45	1,318 of both sexes	?*	0.0	3.8	3.8	?*	7
Lake County (Elev.: 10,000 ft)	1949	1,017	5-23	2.9	9.8	12.8	?*	8
State-wide 6th grade survey	1949-51	11,236	10-13	2.6	6.6	9.4	36.4	6
Durango	1956-58	2,191	5-13	5.5	4.1	9.6	31.2	–
Grand Junction	1958	6,311	5-13	5.2	1.1	6.3	33.0	2

* Figure uncertain or not given.

in Colorado school children, the study of the state-wide sample of 11,236 sixth graders in 1949-1951 stands out.[6] Those examined represented 99.7 per cent of the total sample selected. Two previous surveys[7,8] involved small selected groups of children and are unsatisfactory for the estimation of heart disease prevalence. The results of all Colorado surveys are presented for comparison in Table 5.

The last three studies in Table 5 report similar rates for innocent heart murmurs, which probably reflects similar auscultatory standards. The state-wide sixth grade survey reports AVHD and CHD prevalence rates which differ from those reported by the Durango and Grand Junction surveys while all three report similar innocent heart murmur rates. These differences might be due to the different age compositions of the populations screened. It was shown in the foregoing that age (within the range included in the studies) had no effect upon the occurrence of innocent heart murmurs. Although sufficient data are not available to attempt a similar analysis of AVHD and CHD occurrence, one would expect AVHD to be increasingly prevalent and CHD to be decreasingly prevalent as the age of the population screened increases.

Discussion and Review

Many estimates of AVHD and CHD prevalence have been reported. Early reports[9-29] which concentrated on AVHD and seemed unaware of the existence of CHD should probably be regarded as handicapped by diagnostic limitations. Other studies[30-32] have grouped CHD or AVHD together with other entities in such a way as to prevent satisfactory evaluation. However, many other surveys of heart disease in school children are available for a comparison which must always take into account the fact that only in recent years have clinical CHD diagnoses been made with facility.

In Table 6 there is a comparison of a number of surveys. When the reports were studied closely, some surveys[6,35,42,46,50,76] seemed to have been done with more care than others. A number of reports[34,38,41,44,45,47,49,51-53] have been careless in delineation of the population

at risk of disease, so that the rates quoted are partly conjectural.

A feature of the list of studies in Table 6 is that two particular groups of investigators seem to have worked only in areas in which the populations examined were at extremely high risk of heart disease, particularly rheumatic heart disease.[41,47,49,52] When these studies and one other study[44] are excluded from consideration on the basis of methodologic inadequacies, the CHD prevalence range is 0.2-6.0 per 1,000; the AVHD prevalence range is 0.4-8.3

Table 6—Comparison of Heart Disease Surveys

Location	Date	Population Examined: Routine School Examinations	Population Examined: Examinations by Specialists	Age Range	Heart Disease Rates per 1,000: CHD	Heart Disease Rates per 1,000: AVHD	Heart Disease Rates per 1,000: Both	Per cent of Normals with Innocent Heart Murmurs	References
New York City	1920	44,000	946	?	0.7	4.5	5.2	?	33
New South Wales	1925?*	12,000?	?	6-13	1.2	8.3	9.5	?	34
Boston	1926	119,337	2,311	6-17	0.5	4.5	5.0	?	35
Philadelphia	1928?	10,333	?	6-16	0.9	8.2	9.1	?	36
Detroit	1928-31	946,580	1,884	6-12	0.2	1.2	1.4	?	37
San Francisco	1929-31	91,000?	843	5-18?	1.5	1.7	3.2	?	38
Philadelphia	1934	33,293	863	6-18	0.9	4.8	5.7	?	39
San Francisco	1931-34	86,082	1,197	5-18	2.0	1.5	3.5	?	40
" "	1935?	13,338	197	6-18	1.4	2.2	3.7	?	40
Montana, Wyoming, Arizona	1936?	—	2,813	5-19	2.5	20.2	22.8	?	41
Cincinnati	1936-38	50,531	?	5-14	1.7	1.7	3.4	?	42
Louisville	1936-39	41,905?	?	6-15	1.6	3.6	5.2	?	43
California	1939-41	—	5,815†	5-18	6.5 (4.6)	11.7 (8.2)	18.2 (12.8)	16.4	44
Rural Iowa	1945	5,058?	—	5-19	2.0	2.7	4.7	?	45
San Francisco	1946-47	57,768	698	5-18	2.0	2.4	4.4	?	46
Connecticut	1946-47	—	3,141	11-15	5.7	21.3	27.1	32.0	47
Bristol, Eng.	1943-48	261,600	1,286	4-13	0.4	0.4	0.8	?	48
Connecticut	1948	—	1,229	10-16	8.1	46.4	54.5	41.6	49
Toronto, Ont.	1948-49	74,450	1,171	5-15	2.1	1.6	3.7	?	50
Miami, Fla.	1949-50	—	1,001	10-16	6.0	5.0	11.0	65.5	51
Buffalo, N. Y.	1949-52	71,107	1,281	5-18?	1.8	2.2	4.0	?	76
Madison, Wis.	1951?	—	893	11-13	10.1	28.0	32.5‡	36.7	52
Pensacola, Fla.	1951-52	—	2,600	9-21	3.1	3.8	6.9	?	53
Salt Lake City	?	—	1,552	?	2.5	7.0	9.5	?	54
Rotterdam	1951-54	84,674	1,398	5-15	0.6	1.0	1.6	?	55
Sydney	1955	34,863	364**	5-16	2.1	1.0	3.1	?	56
Chicago	1959-60	27,911	492	6-13?	1.7	0.6	2.3	?	77

* ? indicates figure uncertain or not given.
† From about 8,250 at risk, therefore the rates in parentheses are equally valid.
‡ Five of 29 cases had both AVHD and CHD.
** From a total of 467 referred for reexamination.

per 1,000; and the combined heart disease prevalence range is 0.8-11.0 per 1,000. The results from the three most recent Colorado surveys fall within these ranges which are the best available estimates of heart disease prevalence in elementary school children.

Time trends in the prevalence rates are impossible to assess because many of the earlier studies yielded underestimates due to limitations in the diagnostic abilities of the day and because some smaller and more recent studies may have resulted in maximum estimates made by overly enthusiastic investigators. However, continuing to ignore the above-excluded studies plus the first two studies in Table 5, Tables 5 and 6 indicate that more recent studies are more apt to show that CHD prevalence exceeds AVHD prevalence in children attending elementary school.

Still considering the same group of studies as in the previous paragraph,[2,6,33-40,42,43,45,46,48,50,51,53-56,76,77] there is no valid evidence to confirm the popular impression that AVHD is increasingly prevalent at increasingly extreme north and south latitudes.[51,65] Coburn's original observation[66] described diminished severity of hemolytic streptococcal infections and diminished severity and frequency of acute rheumatic fever in semitropical compared to temperate environments. As mentioned previously, these phenomena are often, but not necessarily always, related to prevalence of rheumatic heart disease, and this disparity has become increasingly important as the over-all severity of hemolytic streptococcal infections and rheumatic fever has gradually and spontaneously diminished over the years.[67,68,70] The possibility exists that post-streptococcal rheumatic fever is only one of several stimuli which may initiate and aggravate chronic progressive valvular fibrosis.

The relatively higher CHD prevalence rates reported recently from school surveys are probably more accurate than earlier reports quoting lower rates. Table 7 presents CHD prevalence rates for various categories of births with varying degree and duration of follow-up. The birth certificate study[58] was reported as being an underestimate because it was realized that many CHD cases do not become manifest until after the certificates have been completed. The two series of hospital births[57,59] are also underestimates because in neither were the infants followed after discharge from the hospital. The New York City and Gothenburg, Sweden, studies[60,62] probably provide the most accurate estimates available. The massive study in Birmingham, England,[61] probably represents the maximum yield which can be obtained from a survey which examines records of children examined by others who are not directly concerned with the study; it must be considered an underestimate. The number of children with CHD who die before reaching school age is at least partially compensated by the number whose CHD becomes manifest after that age.

Summary

Relatively recent advances in surgery and anesthesiology have led to the present highly developed status of cardiac surgery which in turn has led to a highly developed system of diagnosis for congenital heart disease that was not available 15-20 years ago. Previous heart disease surveys in school children have focused on the problem of rheumatic heart disease. Since earlier investigators were unable to diagnose a significant proportion of CHD cases, their estimates of heart disease prevalence are of much less value to us today than may be generally realized.

It is possible that rheumatic heart disease (RHD) is an overly inclusive diagnostic term as commonly used to-

day, since evidence is accumulating that infectious agents other than the hemolytic streptococcus can initiate endocarditis and "rheumatic" valvular deformities. The term "acquired valvular heart disease" (AVHD) deserves wider usage than the term "RHD" except in cases which are specifically known to have suffered acute rheumatic fever. We may be overlooking an etiologically and epidemiologically separate disease when we group those RHD cases without a history of acute rheumatic fever together with those RHD cases with a history of acute rheumatic fever.

Results of screening programs in elementary schools of two Colorado towns are reviewed and show that the age distributions of the two populations screened do differ but not more than the differences between the sexes within each population, which suggests that the two populations are comparable. AVHD prevalence rates differed significantly between the two towns, but CHD and total heart disease prevalence rates did not. The over-all prevalence of innocent heart murmurs was approximately the same in the two towns, and age had no effect upon their prevalence rates in either town within the age range studied. Innocent murmur prevalence was significantly higher in males than females, although there was a significant difference between towns in this respect which tends to detract from the sex difference in innocent murmur prevalence.

The survey results in these two towns were compared with previous Colorado surveys. An excellent earlier study had found a similar total innocent heart

Table 7—Incidence of Congenital Cardiovascular Malformations Among Newborns, Varying Periods of Follow-up

Location	Date	Population at Risk	Cardiovascular Malformation Rate per 1,000	References
Liverpool, England	1923-32	13,964 births in Liverpool Maternity Hospital	0.7	57
New York State	1940-42	273,604 birth certificates	0.5	58
Rochester, Minn.	1944-50	8,716 births in St. Mary's Hospital	2.3	59
New York City	1946-53	5,739 infants weighing over 500 gm at birth	8.5	60
New York City	1946-53	4,693 infants over 500 gm at birth who either had autopsies or were seen at 6 and 12 months of age	8.7	60
New York City	1946-53	5,104 infants weighing over 2,500 gm at birth	5.7	60
Birmingham, England	1940-49	199,418 total births followed for 3-11 years	3.2	61
Gothenburg, Sweden	1941-50	58,105 live births followed for 7-16 years	6.4	62

murmur prevalence rate, a higher AVHD prevalence rate, and a lower CHD prevalence rate than did the recent surveys in Durango and Grand Junction.

To compare Colorado prevalence rates with those from elsewhere, figures were compiled from as many sources as possible. When certain extreme and questionable results were excluded, it was found that total heart disease prevalence rates ranged from 0.8 to 11.0 per 1,000, while CHD rates ranged 0.2 to 6.0 per 1,000, and AVHD rates ranged 0.4 to 8.3 per 1,000. The rates from the Durango and Grand Junction surveys fall within these limits.

More recent surveys tend to show CHD prevalence rates exceeding AVHD prevalence rates. This phenomenon is probably due to a combination of increased ability to diagnose CHD and decreased prevalence and severity of rheumatic fever. The best evidence to date indicates that probably about six to eight cases of CHD will be discovered per 1,000 live births followed for 10-15 years after birth.

REFERENCES

1. Morton, W.; Lloyd, L.; Dodge, H. J.; and Hoffman, M. S. Use of a Single-Lead ECG in the Detection of Congenital Heart Disease. A.M.A. Am. J. Dis. Child. 95:492, 1958.
2. Morton, W.; Beaver, M. E. N.; and Arnold, R. C. Heart Disease Screening in Elementary School Children. J.A.M.A. 169:1163, 1959.
3. U. S. Weather Bureau, Denver, Colo., 1958.
4. Morton, W.; Hoffman, M. S.; Cleere, R. L.; and Dodge, H. J. Comparison of Three Methods of Screening for Pediatric Heart Disease. J.A.M.A. 169:1169, 1959.
5. Snedecor, G. W. Statistical Methods (5th ed.). Ames, Ia.: Iowa State University Press, 1956, p. 518.
6. Maresh, G. J.; Dodge, H. J.; and Lichty, J. A. Incidence of Heart Disease among Colorado School Children. A Statewide Study. J.A.M.A. 149:802, 1952.
7. Wedum, B. G.; Wedum, A. G.; and Beaghler, A. L. Prevalence of Rheumatic Heart Disease in Denver School Children. A.J.P.H. 35:1271, 1945.
8. Wedum, B. G.; Darley, W.; and Rhodes, P. H. Prevalence of Rheumatic Heart Disease at High Altitudes. A.M.A. Am. J. Dis. Child. 79:205, 1950.
9. Holt, L. E. The Problem of the Cardiac Child in New York City. Arch. Pediat. 34:12, 1917.
10. Bainton, J. H. Heart Disease and School Life. A.J.P.H. 18:1252, 1928.
11. Clark, T. Heart Disease, a Public Health Problem. Pub. Health Rep. 44:2463, 1929.
12. Meyers, J. Physical Findings in New York City Continuation School Boys. A.J.P.H. 21:615, 1931.
13. Cohn, A. E. Heart Disease from the Point of View of Public Health. Am. Heart J. 2:275,386, 1927.
14. Allan, G. A. Effects of Rheumatism in Children. Glasgow M. J. 105:118, 1926.
15. Reports on Public Health and Medical Subjects. No. 23. The Incidence of Rheumatic Diseases. London, England: Ministry of Health. His Majesty's Printing Office, 1924.
16. Miller, R. Report on Environment and Other Predisposing Causes of Rheumatic Infection. Brit. M. J. (Suppl.) 2:5, 1926.
17. Kaiser, A. D. Tonsillectomy in Chidren. J.A.M.A. 87:1012, 1926.
18. Benjamin, J. E. The Heart Disease Situation in Cincinnati. Am. Heart J. 2:637, 1927.
19. Hewitt, E. S., and Geddie, K. B. Report of Physical Examination of High School Students. Proc. Staff Meet. Mayo Clinic 6:53, 1931.
20. McSweeney, C. J. Studies in Juvenile Rheumatism. Arch. Dis. Childhood 6:367, 1931.
21. Hill, N. G. The Etiology of Juvenile Rheumatism. Brit. J. Child. Dis. 27:161, 1930.
22. Paul, J. R., et al. The Social Incidence of Rheumatic Heart Disease. Am. J. M. Sc. 188:301, 1934.
23. Paul, J. R., and Deutsch, J. V. Rheumatic Fever in Connecticut, a General Survey. Hartford, Conn.: Connecticut State Dept. of Health, 1941.
24. Maddox, K. Metropolitan and Rural Incidence of Acute Rheumatism and Rheumatic Heart Disease in New South Wales. M. J. Australia 1:425, 1937.
25. Cossio, P. Heart Disease in the Argentine. Am. Heart J. 25:145, 1943.
26. Perry, C. B., and Roberts, J. A. F. A Study on the Variability of Rheumatic Heart Disease within the City of Bristol. Brit. M. J. 2 (Suppl.):154, 1937.
27. Morris, J. N., and Titmus, R. M. Epidemiology of Juvenile Rheumatism. Lancet 2:59, 1942.
28. Clark, P. J. H. The Clinical and Public Health Aspects of Juvenile Rheumatism in Dublin. Irish J. M. Sc. 6th Series: p. 97 (Mar.), 1940.
29. Bach, F.; Hill, N. G.; Preston, T. W.; and Thornton, C. E. Juvenile Rheumatism in London. Ann. Rheumat. Dis. 1:210, 1939.
30. Savage, W. G. Incidence of Rheumatic Heart Disease in Gloucestershire, Somerset and Wilts. Brit. M. J. 2 (Suppl.):38, 1931.
31. Robins, A. B., and Ehrlich, D. E. Group X-Ray Surveys in Apparently Healthy Individuals. Radiology 34:595, 1940.
32. Keith, J. D., and Prequegnat, L. A. Some Observations on the Prevalence of Rheumatic Heart Disease in Canada. Canad. J. Pub. Health 38:111, 1947.
33. Halsey, R. H. Heart Disease in Children of School Age. J.A.M.A. 77:672, 1921.
34. Sutton, H. Heart Disease in Children of School Age and Its Treatment. M. J. Australia 2:272, 1926.
35. Robey, W. H. A Cardiac Survey of Children in Boston Public Schools. Nation's Health 9:21 (Dec.), 1927.
36. Cahan, J. M. Incidence of Heart Disease in School Children. J.A.M.A. 92:1576, 1929.
37. Logan, R. E. Rheumatic Heart Disease in School Children. Illinois M. J. 66:466, 1934.
38. Richter, I. M. Incidence and Variety of Heart Disease in San Francisco School Children. J.A.M.A. 97:1060, 1931.
39. Cahan, J. M. Rheumatic Heart Disease in Philadelphia School Children. Ann. Int. Med. 10:1752, 1937.
40. Sampson, J. J.; Christie, A.; and Geiger, J. C. Incidence and Type of Heart Disease in San Francisco School Children. Am. Heart J. 15:661, 1938.
41. Paul, J. R., and Dixon, G. L. Climate and Rheumatic Heart Disease; Survey among American Indian

School Children in Northern and Southern Localities. J.A.M.A. 108:2096, 1937.
42. Rauh, L. W. Incidence of Organic Heart Disease in School Children. Am. Heart J. 18:705, 1939.
43. Weiss, M. W. Incidence of Rheumatic and Congenital Heart Disease among School Children of Louisville, Ky. Ibid. 22:112, 1941.
44. Sampson, J. J.; Hahman, P. T.; and Halverson, W. L. Incidence of Heart Disease and Rheumatic Fever in 3 Climatically Different California Communities. Ibid. 29:178, 1945.
45. Jackson, R. L. Heart Disease in Children in a Rural Iowa County, Particularly in Regard to Rheumatic Fever. J. Pediat. 29:647, 1946.
46. Robinson, S. J.; Aggeler, D. M.; and Daniloff, G. T. Heart Disease in San Francisco School Children. J. Pediat. 33:49, 1948.
47. Quinn, R. W.; Watkins, J. H.; and Quinn, J. P. Rheumatic Heart Disease and Crowding. A.J.P.H. 38:1071, 1948.
48. Apley, J., and Perry, C. B. A Six Year Survey of the Cases Seen at a School Cardiac Clinic. A.M.A. Arch. Dis. Child. 29:317, 1954.
49. Quinn, R. W.; Liao, S. J.; and Quinn, J. P. An Environmental and Sociological Study of Rheumatic Heart Disease in School Children from Four Connecticut Communities. A.J.P.H. 40:1285, 1950.
50. Gardiner, J. H., and Keith, J. D. Prevalence of Heart Disease in Toronto Children. Pediatrics 7:713, 1951.
51. Saslaw, M. S.; Ross, B. D.; and Dobrin, M. Incidence of Rheumatic Heart Disease in Native School Children of Dade County, Florida. Am. Heart J. 40:760, 1950.
52. Quinn, R. W., and Kincaid, C. K. Rheumatic (Valvular) Heart Disease in Madison, Wis.: A Survey of 7th Grade School Children. Am. J. M. Sc. 223:487, 1952.
53. Packard, J. M.; Graettinger, J. S.; and Graybiel, A. Incidence of Heart Disease in School Children of Pensacola, Florida. J. Florida M. A. 39:30, 1952.
54. Op. cit., personal communication to authors from R. H. Alway.
55. Van Der Meer, P., and Quispel, B., Jr. Frequency of Rheumatic Heart Disease in School Children: Report of a Study on the Rotterdam School Population. Contemporary Rheumatology. London, England: Elsevier Publishing Company, 1956, p. 9.
56. Stuckey, D.; Dowd, B.; and Walsh, H. Cardiac Murmurs in School Children. M. J. Australia 1:36, 1957.
57. Malpas, P. The Incidence of Human Malformations and the Significance of Changes in the Maternal Environment in Their Causation. J. Obst. & Gynaec. Brit. Emp. 44:434, 1937.
58. DePorte, J. V., and Parkhurst, E. Congenital Malformations and Birth Injuries among Children Born in New York State Outside of New York City in 1940-42. New York J. Med. 45:1097, 1945.
59. Harris, L. E., and Steinberg, A. G. Abnormalities Observed during the First 6 Days of Life in 8,716 Liveborn Infants. Pediatrics 14:314, 1954.
60. Richards, M. R., et al. Congenital Malformations of the Cardiovascular System in a Series of 6,053 Infants. Ibid. 15:12, 1955.
61. Macmahon, B.; McKeown, T.; and Record, R. G. The Incidence and Life Expectation of Children with Congenital Heart Disease. Brit. Heart J. 15:121, 1953.
62. Carlgren, L. The Incidence of Congenital Heart Disease in Children Born in Gothenburg 1941-1950. Ibid. 21:40, 1959.
63. Morton, W. Analysis of the V3R Lead As a Mass Screening Device. Am. Heart J. 59:208, 1960.
64. Swan, H., and Blount, S. G., Jr. Proper Selection of Cases for Heart Surgery. Postgrad. Med. 24:143, 1958.
65. Paul, J. R. The Epidemiology of Rheumatic Fever (3rd ed.). New York, N. Y.: American Heart Association, 1957.
66. Coburn, A. F., and Pauli, R. H. Observations on the Ecology of Hemolytic Streptococcus in Relation to the Epidemiology of Rheumatic Fever. J. Exper. Med. 56:609, 1932.
67. Jones, T. D., and Bland, E. F. The Natural History of Rheumatic Fever. Rheumatic Fever, a Symposium. L. Thomas (ed.). Minneapolis, Minn.: University of Minnesota Press, 1952.
68. Wilson, M. G.; Lim, W. N.; and Birch, A. M. The Decline of Rheumatic Fever. Recurrence Rates of Rheumatic Fever among 782 Children for 21 years (1936-56). J. Chronic Dis. 7:183, 1958.
69. Peery, T. M., and Evans, J. M. Brucellosis and Heart Disease. III. Chronic Valvular Heart Disease following Nonfatal Brucellosis. Ann. Int. Med. 49:568, 1958.
70. Bland, E. F. Declining Severity of Rheumatic Fever. A Comparative Study of the Past 4 Decades. New England J. Med. 262:597, 1960.
71. Pearce, J. M. Heart Disease and Filterable Virus. Circulation 21:448, 1960.
72. Ravin, A. Auscultation of the Heart. Chicago, Ill.: Year Book Publishers, 1958.
73. Silber, E. N. Respiratory Viruses and Heart Disease. Ann. Int. Med. 48:228, 1958.
74. Fisher, E. R., and Davis, E. R. Myocarditis with Endocardial Elastomyofibrosis (EEMF). Am. Heart J. 56:537, 1958.
75. Saphir, O., and Rubenstone, A. I. "Pathologic Aspects of Myocarditis." In: Luisada, A. A. Cardiology, an Encylopedia of the Cardiovascular System. New York, N. Y.: McGraw-Hill, 1959, Vol. 3, pp. 8–63 to 8–88.
76. Mattison, B. F.; Lambert, E. C.; and Mosher, W. E. Cardiac Screening in a School Health Program. New York J. Med. 53:2966, 1953.
77. Miller, R. A., et al. Detection of Heart Disease in Children: Results of a Mass Field Trial Using Tape-Recorded Heart Sounds. Paper read at American Heart Association Scientific Meetings, Miami, October, 1961.

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