MORTALITY OF PERSONS WITH PHOTOFLUOROGRAMS SUGGESTIVE OF CARDIOVASCULAR DISEASE

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MORTALITY OF PERSONS WITH PHOTOFLUOROGRAMS SUGGESTIVE OF CARDIOVASCULAR DISEASE*

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The advent of photofluorography has made possible the radiologic screening of the chests of millions of persons each year. Although this method has been largely applied to tuberculosis case finding, many cardiovascular abnormalities have also been detected by this procedure. Since diseases of the cardiovascular system are responsible for an increasingly large number of deaths each year, efforts have been made to determine the potential usefulness of chest photofluorography as a means of detecting persons with cardiovascular disease, with the assumption that patients found in routine surveys might be benefited more by appropriate treatment than those seeking medical care because of symptoms. This assumption is based on the premise that persons who are most likely to die of cardiovascular diseases may in some significant degree be selected from the general survey population by the abnormal appearance of their cardiovascular shadows as revealed by chest photofluorograms. Although it may seem obvious that a cardiovascular shadow of abnormal size or shape is likely to be associated with a fairly serious prognosis, it may be of interest to report the degree to which a community-wide survey was able to select persons from this ambulant population who later died of causes related to the cardiovascular system.

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Although the Muscogee County Tuberculosis Study was primarily designed to investigate the epidemiology of tuberculosis, certain of its data have a bearing on the study of cardiovascular diseases suspected from the examination of chest photofluorograms. As reported previously,\textsuperscript{1,2} the original data were derived from a community-wide tuberculosis and venereal-disease survey conducted in Muscogee County, Georgia, in May and June, 1946. In the course of this survey, 43,429 residents\textsuperscript{4} of the county over the age of fifteen years had 70-mm. photofluorograms of the chest and serologic tests for syphilis. Because the medical officer in charge of the survey was interested in cardiovascular diseases, somewhat more effort than was usual at that time was made both in recording possible cardiovascular abnormalities noted in the interpretations of the survey films and in recalling those with such interpretations for re-examination. These persons were sent a mimeographed letter requesting that they return to the clinic for further examination—those not responding to the first letter were sent a second notice. As a result of these two letters, 80 per cent of this group were re-examined in the clinic. A few more subsequently returned to the clinic for other reasons, so that by January 1, 1950, 83.9 per cent of the group had returned for re-examination.

The clinic examination was of necessity somewhat cursory, being designed primarily to eliminate as many false-positive results as possible before these persons were referred to their own physicians for further study and treatment. It consisted of a brief historical review of the cardiovascular system, physical examination of the chest, blood-pressure determination in the sitting posi-

\textsuperscript{4}“Resident” in this paper is defined as a person giving a Muscogee County address at the time of the survey examination.
tion, and fluoroscopic study of the chest. Full-sized chest films in various positions were taken occasionally. In addition, the results of the serologic tests for syphilis made in this survey were available to the clinician. If the impression from the clinic examination agreed with the survey impression of cardiovascular disease, the person was urged to

seek further medical advice from his own physician, to whom the findings were reported.

Although no further follow-up efforts were devoted to these cases, the data from the master index file of the tuberculosis study is applicable to an analysis of the mortality in this group. Every person examined in the 1946 survey is represented by a card in this file, on which the results of the survey examinations are recorded. Death certificates for all deaths occurring in Muscogee County have been matched against the master index file, and the date and cause of death are recorded.
The study procedures provided no means of measuring emigration from the county or of obtaining information on deaths occurring outside the county during the period covered by this analysis (July 1, 1946, to January 1, 1950). However, there is no known reason to believe that the emigration of persons with cardiovascular disease has been different from that of the rest of the population or that an appreciable number of residents have died outside the county. Thus, for the three and a half-year period after the survey, it is possible to determine the minimum mortality experienced by 739 persons whose cardiovascular shadows on the survey photofluorograms were considered abnormal, and to compare it with that experienced by 42,690 persons whose survey films were classified as giving no significant evidence of cardiovascular disease.

**Prevalence of Cardiovascular Abnormalities Suspected from the Survey Photofluorograms**

Among the persons examined in the 1946 survey there were 43,429 over the age of fifteen years who gave Muscogee County addresses. Of these, 739, or 1.70 per cent, had chest photofluorograms interpreted as indicative of cardiovascular abnormalities. Marked differences in the prevalence of such abnormalities were noted between whites and Negroes, the Negroes showing much higher rates at all ages (Table 1). Males showed a generally higher prevalence of recorded cardiovascular abnormalities among both race groups and at all ages. However, the difference between the sexes in this respect did not seem sufficient to require a further subdivision of the data. The proportion of persons among the white population whose survey films indicated possible cardiovascular disease was approximately 0.1 per cent in the group from fifteen
Historical Paper

to forty-five years of age. This ratio then rose slowly until the age of sixty-five, and reached a peak of 5.3 per cent for the group over that age. The proportion among the Negroes was approximately 0.6 per cent from fifteen to thirty-five, with a subsequent progressive rise to a level of 23.0 per cent among the group over sixty-five. Only 1 out of 36 white persons over the age of fifty-five was classified as suspected of having cardiovascular disease; among the Negroes over fifty-five, 1 out of every 6 was placed in this category.

Although the clinic examinations were too cursory to yield reliable diagnostic data, the types of cardiovascular lesion suspected by the clinician among the persons who returned for examination may be of interest. These impressions (Table 2) show that the greater frequency of abnormalities suspected in Negroes from the 70-mm. survey films could be ascribed largely to hypertensive disease.* Cardiovascular syphilis also appeared to be much more common among the Negroes, as did the category of “widened aorta only,” for which no

*Hypertension was defined in this study as a systolic blood pressure greater than 140 and a diastolic pressure greater than 90. Blood pressures were recorded on the right arm, with the subject seated. Systolic pressures were defined as the level at which sounds were first audible, and diastolic pressures as the level at which the sounds became muffled.
etiologic impression was recorded. These findings are in accord with the observations of others that both hypertension and cardiovascular syphilis are more common among Negroes than among whites.3-5

**Mortality**

Among the 739 persons whose survey photofluorograms were considered to indicate cardiovascular disease, 116 (15.7 per cent) are known to have died in the three and a half years after the survey (July 1, 1946, to January 1, 1950). Table 3 shows the deaths among this group by race and broad age groups. There was an increase in the mortality with age, from about 6 per cent in the group fifteen to thirty-four years old to nearly 20 per cent among those over fifty-five years of age. There was no appreciable difference between the two races in this respect, except for the apparently greater mortality among the whites aged thirty-five to fifty-four than among the Negroes. However, with the small numbers involved the significance of this difference is dubious.

The fact that nearly a sixth of the persons recalled because of suspected cardiovascular disease were dead three and a half years later is quite striking, especially if it is recalled that these persons were all ambulant and, almost without exception, had no disabling symptoms at the time of the survey examination. The mortality rate among this group thus becomes even more impressive when compared to the deaths that occurred in the same period among persons whose survey photofluorograms were classified as negative for cardiovascular disease. These data are also shown in Table 3 by race and by broad age groups. For the whites, the rates were fifteen times higher among those suspected of having cardiovascular disease.
### Table 3. Total Deaths among Residents Surveyed.

<table>
<thead>
<tr>
<th>AGE IN 1946</th>
<th>Survey Negative for Cardiovascular Disease</th>
<th>Surveyed Cardiovascular Disease on Survey</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Survey population</td>
<td>Total deaths</td>
<td>No.</td>
</tr>
<tr>
<td><strong>Whites:</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15–34</td>
<td>13,681</td>
<td>35</td>
<td>0.25</td>
</tr>
<tr>
<td>35–54</td>
<td>8,838</td>
<td>102</td>
<td>1.15</td>
</tr>
<tr>
<td>Over 55</td>
<td>2,253</td>
<td>149</td>
<td>6.61</td>
</tr>
<tr>
<td><strong>Totals</strong></td>
<td>24,772</td>
<td>286</td>
<td>1.15</td>
</tr>
<tr>
<td><strong>Averages</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Negroes:</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15–34</td>
<td>10,622</td>
<td>98</td>
<td>0.92</td>
</tr>
<tr>
<td>35–54</td>
<td>6,112</td>
<td>153</td>
<td>3.15</td>
</tr>
<tr>
<td>Over 55</td>
<td>1,104</td>
<td>84</td>
<td>7.08</td>
</tr>
<tr>
<td><strong>Totals</strong></td>
<td>17,918</td>
<td>375</td>
<td>2.09</td>
</tr>
<tr>
<td><strong>Averages</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
than among those with negative survey findings; for the Negroes, those with survey films classified as indicating suspected cardiovascular disease showed a death rate seven times higher than those with films classified as negative. The differences were most marked in the group fifteen to thirty-five years of age, but even among persons over fifty-five, the death rates for those with films suggesting cardiovascular disease were about three times as high as the rates for those with films classified as being negative for cardiovascular abnormalities.

If the deaths registered as due to renovascular diseases† are studied among the group of persons recalled because of suspected cardiovascular disease, the pattern is similar to that noted for all deaths (Table 4). The reason for the similarity in pattern is that 81 per cent of deaths among this group were reported as due to renovascular disease, a fact that tends to confirm the specificity of the survey-film impression of cardiovascular disease. Within three and a half years nearly 13 per cent of this group of persons died of causes related to the renovascular group of diseases.

With the deaths limited to those from these causes, the comparison with those whose chest photofluorograms were considered negative for cardiovascular disease becomes even more striking than when the comparison is made on the basis

†This classification includes the following causes of death (International List of the Causes of Death, fifth revision):

304 Syphilis — aneurysm of aorta
30b Other syphilis of circulatory system
83 Intracranial lesions of vascular origin
92 Chronic affections of valves and endocardium
93 Diseases of myocardium
94 Diseases of coronary arteries and angina pectoris
95 Other diseases of the heart
96 Aneurysm
97 Atherosclerosis
102 High blood pressure
111 Chronic nephritis
132 Nephritis, unspecified (ten years of age and over)
157 Congenital malformations of the heart
157f Congenital malformations of the cardiovascular system.
of all deaths. The mortality among whites from renocardiovascular causes for the post-survey period of three and a half years was thirty-one times as great among those classified as having cardiovascular disease as among those with films considered to be negative; the ratio for the Negroes was 14. Again the difference between the "cardiovascular suspects" and the "negatives" was greatest in the youngest age group, but was still considerable even among those over fifty-five.

These findings afford strong evidence for the validity of the premise that changes in routine chest photofluorograms interpreted as being suggestive of cardiovascular disease can afford a method for selecting from the general population a small group of persons among whom the risk of dying from diseases related to the cardiovascular system is much greater than that of the rest of the population. Whether or not this group of persons who are thus labeled as having "suspected cardiovascular disease" can be benefited by treatment is another matter, but at least it appears that chest x-ray surveys for cardiovascular disease can fulfill one purpose of a screening examination—namely, to identify among the total surveyed population a relatively small group of persons whose subsequent mortality experience shows that they are in need of further remedial or preventive measures.

Discussion

Because the majority of the persons whose films were interpreted as suggestive of cardiovascular disease were re-examined in the clinic and because these persons were advised to consult their own physicians (to whom a copy of the survey and clinic findings was sent), it is possible that the opinion of the clinic physician influenced the diagnoses subsequently made. This in turn could have influenced
### Table 4. Deaths from Renocardiovascular Causes.

<table>
<thead>
<tr>
<th>Age in 1946</th>
<th>Survey Negative for Cardiovascular Disease on Survey</th>
<th>Suspected Cardiovascular Disease on Survey</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Survey Population</td>
<td>Renocardiovascular Deaths</td>
</tr>
<tr>
<td></td>
<td>no.</td>
<td>%</td>
</tr>
<tr>
<td>Whites:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>15–34</td>
<td>13,681</td>
<td>3</td>
</tr>
<tr>
<td>35–54</td>
<td>8,839</td>
<td>36</td>
</tr>
<tr>
<td>Over 55</td>
<td>2,253</td>
<td>95</td>
</tr>
<tr>
<td>Totals Averages</td>
<td>24,772</td>
<td>134</td>
</tr>
<tr>
<td>Negros:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>15–34</td>
<td>10,622</td>
<td>11</td>
</tr>
<tr>
<td>35–54</td>
<td>6,112</td>
<td>91</td>
</tr>
<tr>
<td>Over 55</td>
<td>1,196</td>
<td>50</td>
</tr>
<tr>
<td>Totals Averages</td>
<td>17,938</td>
<td>152</td>
</tr>
</tbody>
</table>
the cause of death noted on the death certificates and could thus explain in considerable measure the agreement between the survey-film impressions and the death-certificate diagnosis. To explore this possibility, a study was made of the records of persons labeled “cardiovascular suspects” as a result of the survey who were later certified to have died of renocardiocvascular diseases, to determine how often the physician who received a report of the clinic and survey findings later signed the death certificate. This study showed that in only 10 percent of such cases was the death certificate signed by the same physician who received a report from the clinic. In a slightly higher proportion, the clinic records did not definitely specify whether or not a report had been sent. However, even if it is assumed that in all such cases a report was sent to the signer of the death certificate, it would have been possible for the survey examination to have influenced the certified cause of death in only a fifth of this group. Consequently, it does not appear likely that the opinion of the clinic physician had an influence on final certification of the cause of death in a sufficiently large number of cases to have accounted for much of the agreement between the survey film impression and the certified cause of death. In any event, the diagnostic label assigned by the clinic physician could have had no effect on the fact of subsequent mortality, and it has been shown that total mortality among the group with “suspected cardiovascular disease” was considerably greater than that among those classified as “negative for cardiovascular disease.”

The fact has already been noted (Table 1) that Negroes at each age group showed a much higher frequency of chest x-ray findings considered to be suggestive of cardiovascular disease than the whites did. A possible explanation of this differ-
ence is the distribution of various types of heart disease among the two races. Both syphilis and hypertension tend to produce cardiac hypertrophy and changes in the aortic silhouette—changes that are often readily noted in the posteroanterior chest x-ray film. Since both these diseases are more common among Negroes than among whites, it might reasonably be expected that radiographic screening methods would cause more Negroes than whites to be classified as cardiovascular suspects.

However, it is possible that still another factor bearing on the increased prevalence among Negroes of cardiovascular disease suspected from the chest photofluorograms is that Negroes may live longer than whites after cardiovascular changes detectable on the posteroanterior chest film develop. Such cases would then tend to accumulate among the Negro population to a greater extent than among the white. That this may be so is suggested by the mortality rates among persons with films showing “suspected cardiovascular disease” (Tables 3 and 4). The rates are a little higher among whites than among Negroes, the difference being most marked in the group thirty-five to fifty-four years of age. However, the numbers involved are small, and the difference between whites and Negroes is not significant in the usual statistical sense.

Further evidence bearing on this point can be obtained by study of the interval between the survey and the time of death for cardiovascular suspects dying from renal cardiovascular disease (Table 5). Among the white suspects who died of renal cardiovascular causes, 63 per cent died less than twelve months after the survey, as compared with only 25 per cent of the Negro suspects in the same period. This difference is statistically significant. Even when the proportion of suspects dying within
a year of the survey is studied in relation to age, it is found for each broad age group that the mortality among whites exceeds that among Negroes, although the difference between the two races in this respect becomes less marked with increasing age. Consequently, for the population under observation in this study, it appears that Negroes live longer than whites after radiographic evidence of cardiovascular disease develops. This

finding could account for part of the difference observed between the white and Negro populations in the proportion of persons with chest photofluorograms considered suggestive of cardiovascular disease.

It should be noted that it is not known how many persons were examined in the survey because of chest symptoms except that all persons were
ambulant. If the white population whose chest photofluorograms were classified as suggestive of cardiovascular disease had contained a higher proportion of persons with symptoms due to cardiovascular disease than that among Negroes, the differences in early post-survey mortality might be explained by this factor, since persons with symptoms might be expected to die sooner than those who are asymptomatic. Although such specific selection in the survey sample does not seem altogether likely, it must be admitted that there is no direct evidence on this point.

Under the conditions of this community x-ray survey, it has been shown that it was possible to select a group of persons among whom the subsequent mortality was considerable and that most of the deaths were attributed to renocardiovascular disease. Conversely, the proportion of persons subsequently dying from this cause was much lower among those whose survey photofluorograms were considered to be negative for cardiovascular disease. Among the whites, only 12 per cent of the post-survey deaths from renocardiovascular disease occurred among the group classified by the survey-film reader as having suspected cardiovascular disease; among the Negroes, the proportion was 33 per cent. In this respect, the survey procedure failed by a considerable margin to identify all the persons whose subsequent deaths showed them to be extremely important in a consideration of the heart-disease problem in this community.

Although perfection is not to be expected in the use of chest x-ray screening for the detection of cardiovascular diseases, the work of Rutstein et al.4 shows that the yield of significant cardiac disease can be increased considerably if the survey films are interpreted by physicians with specialized train-
ing. This is a factor that merits serious consideration in the planning of screening programs for the detection of cardiovascular disease. However, the present study demonstrates that even without such specialized training, a conscientious survey-film reader was able to narrow down the group to be investigated for cardiovascular disease to less than 2 per cent of the surveyed population, and that the group thus selected yielded a fourth of the deaths from renocardiovascular disease occurring within a subsequent period of three and a half years.

It must be admitted that it is not yet known to what extent death and disability can be decreased among ambulant persons whose chest photofluorograms are classified as indicating suspected cardiovascular disease. This study provides no evidence on this point, except for the impression that the advice given at the time of the clinic examination failed to motivate many of the persons examined to return to their own physicians for treatment and follow-up examinations. In any event, the fact still remains that the group of cardiovascular suspects identified in this mass x-ray survey contributed considerably to the problem of renocardiovascular disease in this community as measured by subsequent mortality. Consequently, in the consideration of measures that may be beneficial in reducing the present incidence of death and disability from these diseases, it seems logical to investigate further the potential usefulness of procedures based on chest x-ray screening of the ambulant population.

**Summary**

In 1946, 70-mm. chest photofluorograms of 43,429 residents of Muscogee County, Georgia, were taken in a community-wide survey. The record system of the Muscogee County Tuberculosis Study
made possible the study of the subsequent mortality experienced by this surveyed population.

Of the surveyed population, 1.70 per cent had chest photofluorograms that were interpreted as indicative of cardiovascular abnormalities. The white population contained a smaller proportion of persons so classified than the Negro, and the difference increased markedly with age. Among whites over the age of fifty-five, only 1 out of 36 was classified as a cardiovascular suspect, as compared with 1 out of every 6 Negroes in the same age group.

Nearly a sixth of the persons suspected of having cardiovascular disease were dead three and a half years after the survey. For the whites, the total mortality among those in the category of suspected cardiovascular disease was 15 times that among those labeled as negative for cardiovascular disease; the ratio for Negroes was 7. The mortality rate from renocardiovascular causes among the whites was 31 times as great for those classified as suspected cardiovascular disease as among those considered negative; the ratio for Negroes was 14.

Among the whites suspected of having cardiovascular disease, 63 per cent of the renocardiovascular deaths occurred during the first year after the survey, as compared with only 25 per cent among the Negroes regarded as cardiovascular suspects during the same period. This difference may partially account for the greater proportion of cardiovascular suspects among the Negro population than among the whites.

Under the conditions of this community x-ray survey, it is shown that it is possible, from the appearance of the cardiovascular silhouette on 70-mm. chest photofluorograms, to select a group of persons whose subsequent experience demonstrates that their risk of dying from renocardio-
vascular causes is very much greater than that of the rest of the surveyed population. The selected group, less than 2 per cent of the surveyed population, yielded nearly a fourth of the renocardiovascular deaths known to have occurred among the surveyed population in the three and a half years after the survey.

The valuable assistance of Dr. Carroll E. Palmer, in charge of Field Research Branch, Division of Chronic Disease and Tuberculosis, United States Public Health Service, is acknowledged.

REFERENCES


5. Ibid. P. 378.