DATA EVALUATION
AND METHODS RESEARCH

Series 2
Number 85

Toward an Index of Preventable Mortality

This report presents a research study on the development of an index that reflects the extent to which an area's mortality rates exceed the lowest possible rates that could be achieved at this epoch in the United States. The index is applied to mortality rates in 19 selected health service areas during 1969-71.

DHHS Publication No. (PHS) 81-1359

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Public Health Service
Office of Health Research, Statistics, and Technology
National Center for Health Statistics
Hyattsville, Md. May 1981

Library of Congress Cataloging in Publication Data

Woolsey, Theodore D.
Toward an index of preventable mortality.

(Vital and health statistics: Series 2, Data evaluation and methods research; no. 85) (DHHS publication; (PHS) 81-1359)
Includes bibliographical references.
Supt. of Docs. no.: HE 20.6209:2/85
1. Mortality—United States—Statistical methods. 2. Death—Causes—Statistical methods. 3. Health status indicators—United States—Statistical methods. 4. United States—Statistics, Medical. 5. United States—Statistics, Vital. I. Title. II. Series: United States. National Center for Health Statistics. Vital and health statistics: Series 2, Data evaluation and methods research; no. 85. III. Series: United States. Dept. of Health. DHHS publication; (PHS) 81-1359. [DNLM: 1. Health surveys—United States. 2. Mortality—United States. W2 A N148vb no. 85]
RA409.U45 no. 85 312'.0723s [312'.2]
ISBN 0-8406-0189-1 80-607087

For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402

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Vital and Health Statistics-Series 2-No. 85

DHHS Publication No. (PHS) 81-1359
Library of Congress Catalog Card Number 80-607087

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TOWARD AN INDEX OF PREVENTABLE MORTALITY

Theodore D. Woolsey, Health Statistics Consultant

INTRODUCTION

Background of the Research

A few words in legislation enacted in 1974 have provided a strong stimulus to research in the development of indexes of health status for small-area populations. It has become almost a standard practice in papers describing the need for or results of this research to call attention at the outset to Public Law 93-641 and, in particular, to Section 1513(b), which requires health systems agencies to compile statistics on the health status, health service utilization, and health resources of the populations they serve. Other legislation, such as that dealing with medically underserved areas, has had a similar effect.

Enactment of these laws and general growth in the field of health policy research have led to a plenitude of papers about the measurement of health status, many of which describe new approaches to this old subject. The following four sources are helpful to those who keep track of the research in progress:[1-4]

1. A conference held at Tucson, Arizona, 1972,[1] conducted by staff of the journal *Health Services Research.*
2. A conference held at Phoenix, Arizona, 1976,[2] conducted by staff of the National Center for Health Services Research, an agency of the U.S. Public Health Service.
3. The *Clearinghouse on Health Indexes,*[3] a continuing summary of work operated by the Division of Analysis of the National Center for Health Statistics.
4. *Health Planning,*[4] a weekly newsletter published by the National Technical Information Service. This abstracting service, in collaboration with the National Health Planning Information Center, reports on papers and technical works on health needs measurement and on other health planning subjects.

Despite the increased research activity evidenced in these sources, there is no consensus on which methods or sources of health status data are suitable for use in the health planning work of the health systems agencies. Agency reports to the Bureau of Health Planning leave the impression that there is as yet little consistency among the agencies' approaches to the measurements of health status.[5] Their reports express goals in terms of statistical quantities, and sometimes in terms of health status measures—particularly the infant mortality rate—but no common strategy for assessing the health problems of the community has emerged.

The failure of the research to lead to any widely accepted practice on the part of the agencies is largely the result of the following two causes in combination:

1. The methods being developed for collecting new statistics are too expensive and, even if applied, would leave the agency with too little opportunity to compare its own measures of health status with those of other communities.
2. Existing data are either believed to be or actually are inappropriate to the measurement of health or are not analyzed in

such a way that they can be used for health measurement.

The research described here is intended to remedy the second cause of failure.

New Measures of Health Status and "Synthetic Estimates"

There is no question that new statistics, specifically designed and collected, could eventually provide more comprehensive and relevant measures of health status than could ever be derived from existing data sources. There is also little doubt that better health status measures would improve the effectiveness of health planning. However, the cost of such new collection would be very high. This is because the collection would probably have to be based on new sample surveys of households,[a] or on surveys of providers of care, or both. The surveys would have to be conducted by every one of some 200 health systems agencies and would be useless unless they were repeated at least twice a decade. (If one estimates an absolute minimum of $200,000 direct costs per survey, the annual budget for such data collection would be about $200,000 X 200 X 1/5, or $8 million per year.) Furthermore, it would be years before the expertise could be summoned to mount such local area surveys on a national basis, and even longer before an analyzable body of data could be gathered.

The availability of comparable statistics on health status over time and space is of critical importance to the health planner. Without the ability to compare statistics for the planner's jurisdiction with statistics of other jurisdictions of similar demographic makeup, or to compare current figures with those for earlier periods, the planner is severely hampered in making intelligent use of health status indicators. Conversely, if comparable statistics could be made available, the planner would have powerful analytical tools to identify emerging health problems, to establish priorities for attacking them, and to measure success in dealing with them. In particular, evaluation of program success or failure in terms of health outcomes, especially given the almost unavoidable absence of truly experimental conditions, must depend upon "before versus after" and "with versus without" comparisons for controls.

It is needs of this sort, coming from the principal users of health status indicators for local areas, that argue against "synthetic" estimates: sophisticated, computerized estimates for local areas based on health statistics from national sample surveys, plus detailed population characteristics of the area from the U.S. Bureau of the Census or other sources. Synthetic estimates are incapable of reflecting changes in health status that do not occur simultaneously in communities with similar population characteristics. Therefore, they are useless for program evaluation.

Premises of the Research

Such considerations led to several premises, and it is on the following that the present research is based:

1. For the time being and for some time to come, the health planner must rely on already available data for constructing indexes of health status.
2. The data must be available not only for a particular health planning jurisdiction to measure health at the present time, but must also be available in comparable form for all U.S. health planning jurisdictions. The data also should cover the past (for at least a decade), as well as permit following trends into the future.
3. Perhaps self-evidently, the indicator must be perceived by the health planner to be appropriate to the measurement of health and "sensitive" to the problems with which the community is concerned.

USE OF MORTALITY STATISTICS TO MEASURE HEALTH STATUS

The figures on numbers of deaths classified by sex, age at death, and other characteristics of decedents have been used to measure the health

[a]For example, the sickness impact profile[6] requires a household sample survey.

of communities for centuries.[7-9] Several recent reports in the series *Statistical Notes for Health Planners,* published by the National Center for Health Statistics (NCHS), have reviewed the uses of mortality statistics and some of the precautions that must be observed in their use.[10-13]

Despite this history, there is a commonly held opinion that mortality statistics are no longer adequate measures of health status, principally because of their alleged "insensitivity."[14] Shapiro argues, however, that whether those who are involved with local health planning should use mortality statistics "as one of the measures of the health status of local area populations" is a "non-issue."[15]

> No evidence on problems of quality of the data or on inadequacy of the information to identify significant health deficits and their correlates can override the unique characteristics of mortality statistics. Simply put, they represent the only continuous source of information on an unequivocal manifestation of health status that dates back many years and is assured of continuity into the foreseeable future, and the data can be examined on a geographically disaggregated level often down to subareas within a city, for example, or aggregated across civil subdivisions for medical market analysis.[15]

The question for the health planner, according to Shapiro, is "how to maximize the utility of this resource."[15] The author of this report cannot express more cogently than that why the research described herein has been launched, but for further background the reader is referred to *Statistical Notes for Health Planners,* No. 3 and No. 6.[11,13]

Statistics on numbers of deaths by cause, age at death, sex, race, and residence of the decedent are available nationally through NCHS and locally through State health departments and health departments of larger cities. NCHS publishes annual volumes containing these figures in summarized form. (For example, the complete detail, by cause and age, is not shown for each sub-State area.) NCHS also makes microdata tapes available from which totals in almost any usable detail can be obtained. The national statistics and those produced by the States do not completely agree, but each year the discrepancies (resulting chiefly from differences in coding practices) are fewer and smaller as a result of cooperative activities between the jurisdictions.

GENERAL PLAN OF THE RESEARCH

Two phases of the research are presented in this report. They are as follows:

1. The rationale and the methods used for determining a set of standard death rates, specific for age, sex, and cause of death, are discussed. The standard death rates are intended to be the lowest possible rates that could be achieved at this epoch in the United States assuming: (a) the best scientific knowledge now available about methods of prevention and treatment of disease and injury, and (b) the successful application of this knowledge in an optimum system of health care, accessible to everyone. These standard death rates will be referred to as "achievable target death rates."
2. Experiments in using achievable target death rates and actual mortality rates in health service areas (HSA's) as the basis for various forms of mortality indexes are detailed. Tests of these forms are examined to learn whether any one form has advantages over another in terms of "sensitivity," a term to be defined later.

Finally, some recommendations for the course of future research and for needed tabulations of mortality data by cause of death are presented. It is hoped that these will facilitate further research and permit HSA's to begin "market testing" of the indexes developed.

ACHIEVABLE TARGET DEATH RATES

Why Such a Standard?

Why should the effort be made to arrive at a standard set of death rates such as those conceived here? Up to this point, it has been customary in this country to use death rates in the

United States as a whole as the normative standard for local area indexes.[11]

The objection to using national death rates as a standard is that statistical comparisons with them, either in the form of absolute differences or ratios, tend to give insufficient weight to those categories of deaths that the health care system can and should be attempting to reduce. For example, one reason that infant mortality rates in the United States are not as low as they could be is that mortality among black infants is currently (1976) about 75 percent higher than it is among white infants. Yet there is no intrinsic reason why that should be so. A community's health problems should be measured in terms of how far its experience differs from what could be achieved, not in terms of how far it differs from a standard that itself reflects failures.

Furthermore, the use of a set of death rates that represents the lowest ones achievable, given successful application of present knowledge, provides a standard that only needs to be modified at intervals of a decade or more. Thus the resulting index yields more valid comparisons over time.

The use of a standard classified by cause of death, as is proposed here, reflects a conviction that at least some degree of disaggregation is needed, according to the type of health problem, in order to provide health status indicators that can do more than just satisfy the curiosity of the health planner. Does it really help to know that the all-causes standardized mortality ratio for Alabama HSA 01 is about 3 percent above what it would be if the national death rates by age, color, and sex were being experienced? The answer is probably, "Yes, but it does not help much." To know how causes of death related, for example, to hypertension, to air pollution, to alcoholism, or to emergency health services in that same community compare with some achievable standard would appear to have far more immediate applicability.

First Considerations

Having defined what the standard set of death rates is intended to represent (see "General Plan of the Research"), the following questions needed to be answered:

1. In what demographic detail should the standard set of death rates be expressed?
2. Specifically, what cause-of-death categories should be used?
3. Most critically, how should the minimum achievable levels be determined?

The first question was easily answered. It has long been recognized that age at death is a critical variable when mortality statistics are being used to compare the health status of communities. Because of the very steep increase in death rates from all causes combined with advancing age, and owing to the heavy influence of age on death rates for almost all cause-of-death groups, it is almost essential that the experience in different age groups be examined separately, or that age be held constant in making comparisons between areas or over time. The latter method is the basic element of most indexes of mortality that have been devised and used in the past.[11]

NCHS uses several standard age-at-death classifications, among which is an 11-group classification starting with "under 1 year of age," followed by "1-4 years," and then eight 10-year groups including "75-84 years," and finally "85 years and over." This classification was adopted for the target achievable death rates.

It was also decided that rates should be determined separately for males and females but not for the color dichotomy, white people versus all other people, so frequently used in categorizing vital statistics in the United States. The reason for omitting this dichotomy has perhaps already been made clear: It was believed there should be no different standard for minority groups. Of course, this does not mean that in calculating mortality indexes one would not examine the situation in the minority populations whenever possible; in fact, such analysis often might help to pinpoint health problems in the specific community.

The disaggregation by cause of death obviously introduces problems that are not encountered when deaths from all causes are combined. One problem is that of small numbers of deaths in the time period and geographic area of concern. These small numbers result in unstable indexes arising from chance variation. This question will be examined in some detail in later sections in which tests of the indexes are presented.

A related problem is the organization of the cause-of-death categories into meaningful and useful groups without introducing too much difficulty in the way of small numbers. The units of the groups are the 4-digit rubrics of the *International Classification of Diseases, Adapted.* In this report all the data used are in terms of the *Eighth Revision International Classification of Diseases, Adapted* (ICDA-8).[16] Furthermore, the groups have purposely been kept consistent with one of the NCHS standard recodes. This is known as the "69-cause list." (Adaptation to the Ninth Revision, the classification now in use, should not pose any particular difficulties.) However, the degree of detail in the 69-cause recode is far too great for the purposes of this report. Some cause-of-death groups are each no more than 0.00001 of the total. It was arbitrarily determined that for local areas the size of HSA's, no cause-of-death group could be used that amounts (for all ages, both sexes, in the United States as a whole) to less than 1 percent of the total.

In arriving at decisions about cause-of-death groups, direct relevance to potential health problems in the community argues for greater detail, but the avoidance of overly small numbers of deaths and the need to keep from producing a bewildering array of statistics when all indexes for a community are compiled weigh the scale heavily toward lesser detail. The compromise reached in initial effort was 16 categories that add to all deaths. However, this particular compromise was not entirely satisfactory, and in subsequent stages of the work somewhat more detail will be used.

The specifics of the groups used are a matter of major importance in maximizing the usefulness of mortality data as indicators of health status problems that normally concern a community. As has been pointed out elsewhere,[13] there are some kinds of problems (e.g., mental disease and mental retardation, problems of undernutrition or overweight, problems of sensory impairments, and the disabilities resulting from arthritides) for which death statistics are so poor as to be nearly useless indicators. But an intelligent grouping of the causes of death, specifically designed to meet the needs of community health planning, can, nevertheless, greatly help to specify the particular problems of the population of the area.

The selection of cause-of-death categories to determine an acceptable set of rates was also strongly influenced in the initial stages by the past practices of NCHS in reporting vital statistics. It had been decided by this author that the calculations of indexes would be demonstrated using the 1969-71 death statistics for a sample of HSA's defined geographically exactly as in the NCHS report "Standardized Mortality Ratio and Years of Life Lost Index: State and Health Service Areas, 1969-71," *Statistical Notes for Health Planners,* No. 3, Data Supplement.[12] For practical reasons, the numbers of deaths by cause for the HSA's were obtained by summarizing already available statistics for counties. These statistics had already been tabulated using the aforementioned 69-cause recode. Any combination of ICDA-8 codes inconsistent with that recode would have required retabulating a large data base to obtain material for the demonstration. It might also have resulted in establishing standards for categories not ordinarily used by NCHS.

An alternative basic data source for illustrative material that was considered and rejected was a data tape created at the Univeristy of Missouri by Professor Herbert I. Sauer.[b] The tape contains numbers of deaths and death rates for selected causes of death by sex and age for each U.S. county for the 4-year period, 1968-72. The reason for not using this otherwise valuable data source was that the cause-of-death groups did not correspond to those being published each year by NCHS.

It would also have been preferable to calculate the indexes for a more recent period of time but, as will be seen, local population data are needed, and the most recent point for which these were available in the detail required was

[b]See p. 7 of reference 13 for a description of the data tape. Professor Sauer can be addressed at the University of Missouri, 111 Professional Bldg., 909 University Ave., Columbia, Mo. 65201.

the time of the 1970 census enumeration. These considerations and the need to adhere to the criterion that no category should include less than 1 percent of all deaths led to the following grouping:

Cause-of-death group	*ICDA-8 code*[16]
Malignant neoplasms of digestive organs and peritoneum	150-159
Malignant neoplasms of respiratory system	160-163
Malignant neoplasms of breast	174
Malignant neoplasms of genital organs	180-187
All other malignant neoplasms	Remainder of 140-209
Diabetes mellitus	250
Diseases of the heart	390-398, 402, 404, 410-429
Hypertension and stroke	400-401, 403, 430-438
Diseases of the arteries, arterioles, and capillaries	440-448
Acute bronchitis, influenza, and pneumonia	466, 470-474, 480-486
Bronchitis, emphysema, and asthma	490-493
Major digestive diseases, except cirrhosis of the liver	531-533, 540-543, 550-553, 560, 574-575
Cirrhosis of the liver	571
Congenital anomalies and diseases of early infancy	740-759, 760-778
All other diseases	Remainder of 000-799
Accidental injuries and other trauma	E800-E999

The most obvious shortcomings of this grouping are the lumping together of All traumas (E800-E999 in ICDA-8 classification) and the combining of Infective and parasitic diseases (000-136) with All other diseases. Each of the classifications Motor vehicle accidents (E810-E823), All other accidents (E800-E807, E825-E949), Suicide (E950-E959), and Homicide (E960-E978) constitutes more than 1 percent of all deaths, and they are health problems of such disparity that it is inappropriate to combine them in the standard. Infective and parasitic diseases, on the other hand, make up a trifle less than 1 percent of all deaths in the country as a whole. In problem areas, however, they might exceed that by a considerable amount, and they clearly represent a distinct kind of health problem, one which requires different solutions.

During the next stage of the research it would also be desirable to revise the grouping of cardiovascular diseases. The Ischemic heart diseases (410-413) should have a separate standard, and Hypertensive heart diseases (402, 404) might better be combined with Hypertension and stroke. Another change that would be an improvement would be to group Chronic obstructive lung disease, now coded separately, with Bronchitis, emphysema, and asthma (490-493), because of the increasing use of the more generalized term on death certificates. This change will become possible with the beginning of use of the *Ninth Revision of the International Classification of Diseases* (ICD-9). There is no obstacle (other than the need for special tabulations) to such changes as these, but they should be considered in the light of the changes needed to convert the system to ICD-9.

Two Methods That Proved Unsatisfactory

Before describing the method finally used to estimate the achievable target death rates for the 11 age groups and 16 cause-of-death groups for males and females (352 values), it is essential to an understanding of the rationale for the choice of method to describe in some detail two methods that were investigated and rejected.

It was first supposed that expert judgments about achievable target death rates could be obtained as a byproduct of another study. This was the study of economic costs of diseases and illnesses conducted for the National Institutes of Health by the Georgetown University Public Services Laboratory.[17] As a part of that study, a forecast of U.S. death rates by age and sex for the major cause-of-death groups in the year 2000 was needed. Instead of relying entirely on projections, as the Social Security Administration has done in the forecasts it uses,[18] the Public Services Laboratory called upon individual experts—statisticians, epidemiologists, and medical specialists—to forecast the death rates by making use of trend data through 1974. No less than five experts were used for each cause-of-death group. For Malignant neoplasms the panel included cancer epidemiologists and oncologists; for Cardiovascular diseases, epidemiologists who had worked in that field and cardiologists were included; and so forth. The figures actually used in the study were based upon arithmetic averages of the forecasts for each cause-age-sex cell, with the most optimistic and most pessimistic extremes excluded. For some cause groups, such as Accidental injuries, no panels were involved; the Social Security Administration's estimates for the year 2000 were substituted instead.

Although this task was clearly not directly comparable to the one of making judgments about achievable target death rates, it seemed to involve many of the same thought processes and had the advantage of bringing to bear the expertise of a number of extremely knowledgeable people. Hence, the first effort made in the present research was to adapt the results of the Public Services Laboratory study to this new purpose.

Very shortly it became evident that the rates of actual events were lower than the expert predictions in a number of the disease groups. Particularly in some major areas of the country, death rates in 1969-71 throughout the age range were consistently below those forecast for the year 2000. Furthermore, death rates for some causes, especially Hypertension and stroke, were falling very rapidly in the mid-1970's. If the predicted rates were to be used as targets, the population of many HSA's would have been found to have progressed beyond the targets even before they began to be applied. Hence this set of data was not used any further.

An idea that conceptually came much closer to that of the achievable target death rate was being developed by the Working Group on Preventable and Manageable Diseases in collaboration with NCHS. This group listed the diseases in which the occurrence of a single case of disease or disability or a single untimely death would justify asking, "Why did it happen?"[19,c] In particular, the list includes the ICDA-8 Revision, code number, and title of all conditions, cases of which could have been prevented or managed "if everything had gone well."

The idea of using an event of this sort as a warning signal is not new, as the Working Group points out, and Rutstein has strongly advocated the use of such "sentinel events" as the basis of a guidance system for national health care.[20] The Working Group also foresees the use of the list as "a tool to measure the baseline state of health and of comparative health status measurements in health service area (HSA) populations."[21]

Beginning efforts to build the counts of sentinel events into a quantitative index of health care quality are now being seen.[22] That an index of health care quality can also serve as an index of health status, or vice versa, is made possible by the nature of this particular method of measuring quality, in which "quality" is defined as "the effect of care on the health of the individual and the population."[19]

Despite the apparent congruence of the ideas, the list of conditions from which deaths are deemed to be unnecessary was rejected as a basis for constructing achievable target death rates. The reasons for this were principally the three following:

1. Death from a particular disease condition was labeled "unnecessary" by the Working Group if the condition was preventable or manageable. In some instances all cases of the disease were covered; in other instances only deaths occurring under a certain age or cases resulting from a particular risk factor were considered preventable or manageable. To determine from these latter qualifications what proportion of all deaths ascribed to that disease could have been prevented requires a great deal of data that are not available. For example, if death from thyroid carcinoma is preventable when the carcinoma resulted from radiation exposure, what proportion of all deaths from this cause are unnecessary?
2. Many numerically important causes of death were not listed at all. For example, nothing is said about Ischemic

[c]The tables of reference 19 were revised as of 9/1/77. Reprints of the article with the revised tables can be obtained from Dr. Rutstein at the Countway Library, Harvard Medical School, 10 Shattuck St., Boston, Mass. 02115.

heart disease, nor about Malignant neoplasms of the breast, nor about Automobile accident injuries. Although these may not be suitable sentinel events, one certainly cannot say that none of these deaths are unnecessary. The result of the omission of these major causes of death from the list is that the fraction of all deaths considered to be unnecessary is quite small. (Different workers have reached different conclusions about this proportion, depending upon what assumptions are made about those items qualified by risk factors. The estimates range from 3 percent, calculated as a part of this research, to 14 percent.[23])

3. Although age is introduced as a qualifying factor for a number of disease conditions, it might well have been a consideration in many others had age been routinely considered as a variable. Deaths from the cerebrovascular diseases offer an appropriate example. Roughly 10 percent of all deaths were classified in this group of diseases in the United States in 1977, but nearly two-thirds of these occurred at age 75 years and over. Although only rarely could death from stroke at an age beyond 75 have been prevented "if everything had gone well," the same cannot be said of the 6 percent of this important group that occurred at ages under 55 years. For a quantitative measure of unnecessary deaths to become credible and useful, age at death must be routinely introduced.

Use of Geographic Variation

In 1967, Guralnick and Jackson showed how geographic variation in mortality by cause of death could be used for establishing an index of unnecessary deaths.[24] They pointed out that the idea had originated with Dr. William Farr, as did so many commonsense ideas. Beginning in 1839, Dr. Farr was superintendent of the Statistical Department of the Office of the Registrar General of England, and he made contributions to the use of mortality statistics for 40 years. He used mortality in the districts of England in which sanitary conditions were least unfavorable as a standard against which to measure the health of residents of other areas.

Guralnick and Jackson applied the same principle to compute "excess" deaths by cause of death and age in two illustrative States. They ranked the State cause-specific death rates in each age group from 1 to 75 years and averaged the lowest five rates. The resulting set of death rates by age and cause was used to estimate "expected deaths" in the two test States. The difference between observed and expected deaths was taken to be the measure of unnecessary deaths, and the proportion of all deaths that these constituted was the unnecessary death index or UDI.

The advantages of this method of establishing a standard are that it is completely reproducible, it requires no individual judgments except as to the details of the method, and it involves only one easily understood assumption: Mortality achieved somewhere in a particular age group and cause-of-death group can also be achieved in other areas.

The assumption, although simple, is not necessarily true. The target death rates are intended to be achieved through the successful application of all present-day knowledge of prevention and treatment. On the one hand, suppose that the lowest death rate from diabetes among middle-aged males is found to be in area A. This is almost certainly not the lowest that could be achieved in area A by application of the best prevention and treatment. Thus the figure may represent an overestimate of the target as it is conceived.

On the other hand, there may be factors, such as the genetic composition of the population, that are partly responsible for the low rate in area A but which area B cannot possibly control by any application of prevention or treatment. This has the result of providing a target that is too low in relation to the intended one.[25]

Nevertheless, the advantages cited, particularly that of being completely reproducible, are believed to outweigh the disadvantages. A standard determined in this way can at least be used in experimentation and "market testing" of indexes.

Methodology and Results

The variability of mortality from one geographic area to another was investigated using a tabulation of death rates by cause and age for white males and white females in the nine geographic divisions of the United States in the period 1969-71. The geographic divisions are the standard ones used for tabulations by the U.S. Bureau of the Census and throughout the Federal statistical system. Mortality of white persons, rather than total mortality, was taken as the basis for the standard because it is generally lower than total mortality and represents an achievable target for minority group mortality as well. The cause-of-death groups were those already presented, except that the five subcategories of malignant neoplasms were not separately analyzed by geographic division. The target rates for all malignant neoplasms in each age-sex group were split into the site subcategories in the same proportions as they are in the United States as a whole. This was a temporary device adopted because suitable data for analyzing each site separately were unavailable.

The first step in analyzing a cause-sex group was to rank the death rates in the white population for the 9 geographic divisions for each of the 11 age groups. The second step was to apply an arithmetic adjustment for trend between the period 1969-71 and 1976 to the lowest of the death rates. This adjustment was made only for

Table A. Estimating achievable target death rates for males aged 1-85 years and over for bronchitis, emphysema, and asthma: United States, 1969-71 and 1976, and geographic divisions, 1969-71

Area and year	Under 1 year	1-4 years	5-14 years	15-24 years	25-34 years	35-44 years	45-54 years	55-64 years	65-74 years	75-84 years	85 years and over
United States:											
1969-71	3.9	0.7	0.2	0.3	0.5	2.4	12.7	60.3	172.6	278.7	282.0
1976	2.5	0.5	0.1	0.2	0.4	1.1	7.1	34.6	113.2	215.2	245.8
New England:											
1969-71	3.9	0.7	0.2	0.3	0.6	2.2	10.7	52.0	160.6	266.8	302.2
Middle Atlantic:											
1969-71	3.6	0.9	0.3	0.3	0.5	2.1	9.4	45.5	137.7	229.2	249.8
East North Central:											
1969-71	3.4	0.7	0.2	0.4	0.5	2.5	12.0	61.4	177.6	292.7	289.2
West North Central:											
1969-71	3.1	0.8	0.2	0.4	0.4	2.4	12.8	57.6	170.0	265.8	260.1
South Atlantic:											
1969-71	3.7	0.4	0.3	0.3	0.5	2.6	15.7	72.4	174.9	268.8	260.0
East South Central:											
1969-71	4.2	0.9	0.2	0.4	0.5	2.5	16.2	70.9	181.4	252.7	257.8
West South Central:											
1969-71	5.0	1.0	0.2	0.4	0.6	2.2	14.2	58.8	175.4	295.7	281.4
Mountain:											
1969-71	3.1	0.1	0.2	0.7	0.8	2.8	19.7	97.5	267.7	401.7	338.7
Pacific:											
1969-71	4.8	0.6	0.2	0.3	0.5	2.6	12.1	60.8	191.5	324.8	339.8
	Preliminary achievable target death rates[1]										
United States:											
1969-71	2.0	0.1	0.1	0.2	0.3	1.0	5.3	26.1	90.3	177.0	217.7
	Smoothed values[2]										
United States:											
1969-71	1.7	0.1	0.1	0.1	0.3	0.8	5.5	27.0	89.4	174.3	

[1]Obtained by multiplying the lowest rate in 1969-71 by U.S. rate for 1976 and dividing by U.S. rate for 1969-71.
[2]For smoothed values read ratios from curve in figure 1 and multiply by U.S. rate for 1976.

rates that had declined during this interval. If the rate had increased, no adjustment was made. The reasoning was that if the lower rate had been reached at the earlier period, it should be possible to reach it again. Thus, if the national death rate among white people for a particular age-sex-cause group had declined 10 percent in that period, the lowest rate among the geographic divisions was assumed to have declined 10 percent also, but if it had increased, the lowest geographic rate for 1969-71 was used without change. This resulted in a set of preliminary target rates for the 11 age groups in the cause-sex group.

The third step was the introduction of a smoothing process to remove some of the effects of random variation in the adjusted lowest death rates. It was carried out by plotting the ratio of the preliminary target rate to the 1976 national death rate for each of the 11 age groups for each cause-sex category. The smoothing was performed on ratios of the preliminary target rates to the most current national death rates then available on the grounds that such ratios should have a more stable relationship to age at death than the achievable target death rates themselves. It was hypothesized that, unless the data strongly indicated otherwise, the ratios should

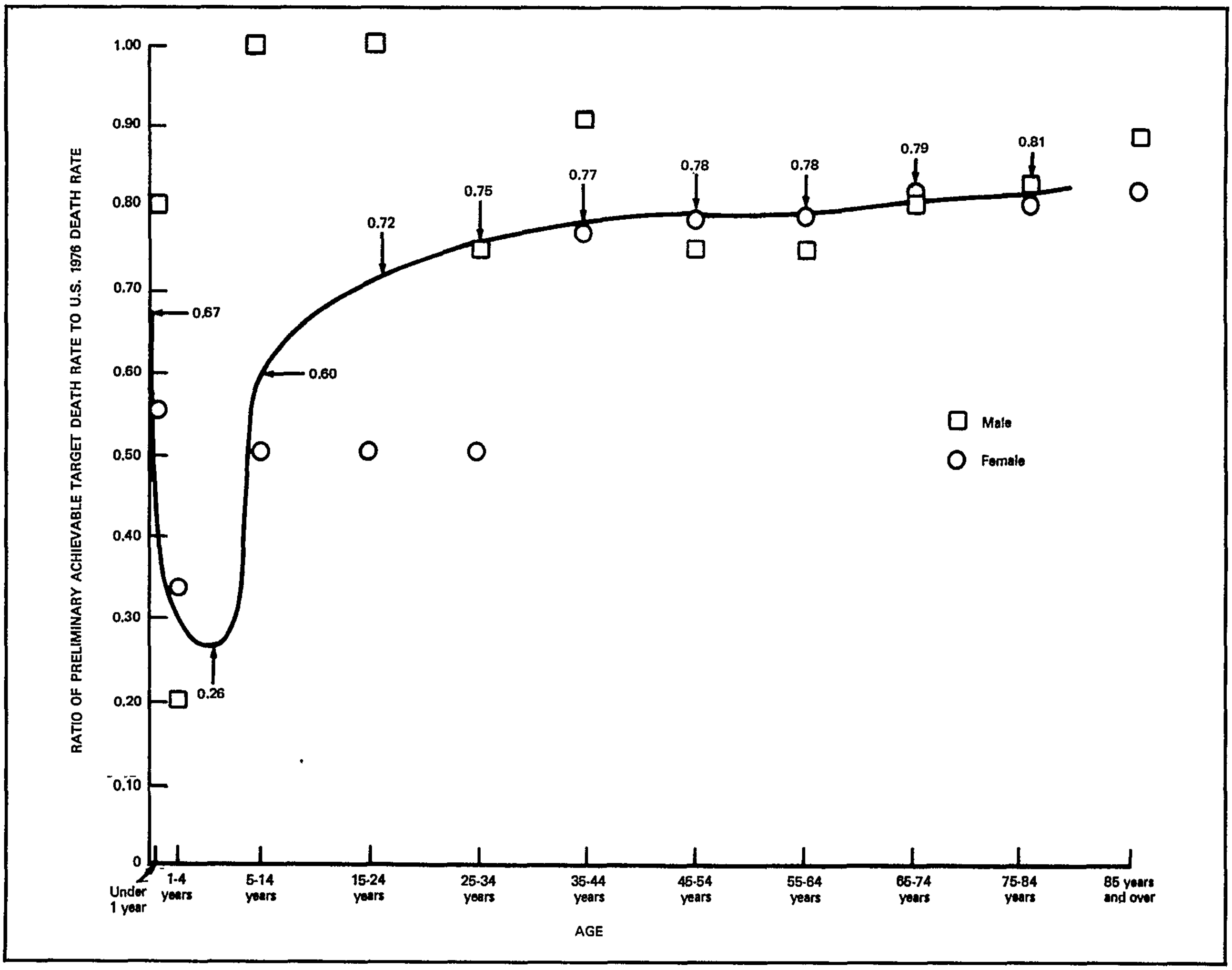

Figure 1. Illustration of smoothing process for achievable target death rates: bronchitis, emphysema, and asthma

increase with age because for most causes of death the proportion preventable should decline with age. Through the 11 plotted points a smooth curve was run using a flexible ruler. The procedure followed was to allow no more than two inflection points in the curve. A rule like this is needed in fitting what is essentially a free-hand curve to prevent the curve from passing through, or close to, all data points. The ratios to two significant figures were read off the plotted curve, and the product of these and the corresponding national rates were the final target rates.

In performing these steps, the age group 85 years and over was omitted. This resulted from an arbitrary decision that no deaths at age 85 years or over would be considered preventable. Hence, the target achievable death rate for that

Table B. Achievable target death rates by sex, cause of death, and age

[Rates per 100,000 population]

Sex, cause-of-death group, and ICDA-8 code[1]	Under 1 year	1-4 years	5-14 years	15-24 years	25-34 years	35-44 years	45-54 years	55-64 years	65-74 years	75-84 years
Male										
All causes	1,246.6	55.3	32.2	122.6	122.1	214.8	610.0	1,574.1	3,565.3	8,038.6
All malignant neoplasms	1.8	4.7	5.6	7.3	12.5	37.7	149.2	417.1	876.0	1,481.1
Malignant neoplasms of digestive organs and peritoneum ... 150-159	0.1	0.1	0.1	0.2	1.4	6.8	31.8	94.5	217.3	392.1
Malignant neoplasms of respiratory system ... 160-163	0.1	0.1	0.1	0.2	1.4	13.5	70.8	172.5	299.9	353.7
Malignant neoplasms of breast ... 174	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Malignant neoplasms of genital organs ... 180-187	0.1	0.1	0.1	1.0	1.2	1.0	2.3	17.2	92.6	273.3
All other malignant neoplasms ... Remainder of 140-209	1.5	4.4	5.2	5.8	8.5	16.4	44.3	132.9	266.2	462.0
Diabetes mellitus ... 250	0.0	0.0	0.0	0.2	1.3	3.0	6.6	19.3	48.3	111.7
Diseases of the heart ... 390-398, 402, 404, 410-429	8.7	0.9	0.5	2.1	8.1	61.6	258.5	705.2	1,579.0	3,587.9
Hypertension and stroke ... 400-401, 403, 430-438	2.5	0.4	0.4	0.9	2.5	7.0	20.9	73.7	277.8	994.0
Diseases of the arteries, arterioles, and capillaries ... 440-448	0.3	0.0	0.1	0.2	0.5	1.5	6.8	31.3	110.2	342.4
Acute bronchitis, influenza, and pneumonia ... 466, 470-474, 480-486	46.8	2.6	0.8	1.2	1.8	4.2	9.8	26.3	81.1	356.9
Bronchitis, emphysema, and asthma ... 490-493	1.7	0.1	0.1	0.1	0.3	0.8	5.5	27.0	89.4	174.3
Major digestive diseases, except cirrhosis of the liver ... 531-533, 540-543, 550-553, 560, 574-575	12.7	0.3	0.2	0.2	0.4	1.6	4.3	11.5	31.7	77.3
Cirrhosis of the liver ... 571	0.1	0.0	0.0	0.1	1.7	10.0	25.1	38.6	40.0	29.8
Congenital anomalies and diseases of early infancy ... 740-759, 760-778	948.8	7.7	1.7	1.3	1.2	1.0	1.5	2.1	2.0	2.1
All other diseases ... Remainder of 000-799	190.9	14.4	5.0	10.4	12.9	23.8	58.8	142.9	321.7	674.6
Accidental injuries and other trauma ... E800-E999	32.3	24.1	17.7	98.6	78.9	62.6	63.0	79.1	108.1	206.5
Female										
All causes	959.7	42.4	19.1	41.0	55.0	122.3	327.8	782.7	1,786.8	5,117.3
All malignant neoplasms	2.1	4.2	3.7	4.7	12.7	45.6	142.3	302.4	490.3	814.6
Malignant neoplasms of digestive organs and peritoneum ... 150-159	0.1	0.1	0.1	0.1	1.1	5.9	20.2	58.1	133.6	281.1
Malignant neoplasms of respiratory system ... 160-163	0.1	0.0	0.0	0.1	0.6	6.0	23.7	45.6	53.0	62.0
Malignant neoplasms of breast ... 174	0.0	0.0	0.0	0.1	3.1	11.2	32.9	56.1	76.9	103.8
Malignant neoplasms of genital organs ... 180-187	0.1	0.1	0.1	0.4	1.6	6.2	17.4	35.3	55.8	80.7
All other malignant neoplasms ... Remainder of 140-209	1.8	4.0	3.5	3.4	6.2	16.3	48.0	107.3	171.0	287.1
Diabetes mellitus ... 250	0.0	0.0	0.0	0.2	1.0	2.1	5.8	17.3	46.3	118.6
Diseases of the heart ... 390-398, 402, 404, 410-429	6.0	0.7	0.5	1.1	3.0	14.7	62.1	222.9	683.9	2,273.1
Hypertension and stroke ... 400-401, 403, 430-438	1.9	0.3	0.3	0.7	2.6	8.2	21.3	57.6	203.6	889.7
Diseases of the arteries, arterioles, and capillaries ... 440-448	0.5	0.0	0.0	0.1	0.3	1.0	3.4	11.1	42.7	212.1
Acute bronchitis, influenza, and pneumonia ... 466 470-474, 480-486	39.2	2.3	0.8	1.0	1.4	2.7	6.2	12.9	37.4	194.9
Bronchitis, emphysema, and asthma ... 490-493	1.1	0.1	0.1	0.1	0.3	1.0	3.6	10.5	20.5	33.2
Major digestive diseases, except cirrhosis of the liver ... 531-533, 540-543, 550-553, 560, 574-575	9.4	0.2	0.1	0.1	0.3	0.9	2.5	6.5	16.8	54.0
Cirrhosis of the liver ... 571	0.1	0.0	0.0	0.0	0.7	4.5	11.8	16.9	15.7	13.1
Congenital anomalies and diseases of early infancy ... 470-759, 760-778	744.7	8.0	1.7	1.0	0.9	1.0	1.4	1.6	1.6	1.8
All other diseases ... Remainder of 000-799	126.6	9.8	3.9	6.9	11.4	19.9	41.4	91.4	181.6	397.0
Accidental injuries and other trauma ... E800-E999	28.1	16.7	7.9	25.1	20.4	20.7	26.0	31.6	46.4	115.2

[1]From the National Center for Health Statistics: *Eighth Revision International Classification of Diseases, Adapted for Use in the United States.* PHS Pub. No. 1693. Public Health Service. Washington. U.S. Government Printing Office, 1967.

age group is whatever death rate is actually experienced. Table A shows a typical worksheet for the computations, and figure 1 shows the corresponding curve for smoothing. In table B the final achievable target death rates are displayed, and in table C these are shown again in the form of ratios to the U.S. national death rates in 1976. In table C the denominators are

Table C. Ratio of achievable target death rates to U.S. death rates in 1976, by sex, cause of death, and age

Sex, cause of death group, and ICDA-8 code[1]	Under 1 year	1-4 years	5-14 years	15-24 years	25-34 years	35-44 years	45-54 years	55-64 years	65-74 years	75-84 years
Male										
All causes	0.71	0.71	0.76	0.73	0.64	0.65	0.73	0.79	0.82	0.85
All malignant neoplasms ... 140-209	0.53	0.84	0.97	0.91	0.89	0.81	0.79	0.80	0.83	0.83
Diabetes mellitus ... 250	0.0	0.0	0.0	0.50	0.65	0.65	0.66	0.68	0.70	0.76
Diseases of the heart ... 390-398, 402, 404, 410-429	0.33	0.43	0.56	0.62	0.68	0.77	0.81	0.84	0.85	0.87
Hypertension and stroke ... 400-401, 403, 430-438	0.54	0.50	0.67	0.64	0.68	0.58	0.59	0.71	0.80	0.88
Diseases of the arteries, arterioles, and capillaries ... 440-448	0.38	0.0	1.00	0.50	0.56	0.65	0.77	0.86	0.92	0.96
Acute bronchitis, influenza, and pneumonia ... 466, 470-474, 480-486	0.63	0.58	0.80	0.71	0.62	0.62	0.65	0.71	0.79	0.88
Bronchitis, emphysema, and asthma ... 490-493	0.61	0.20	0.50	0.33	0.60	0.62	0.73	0.79	0.83	0.86
Major digestive diseases, except cirrhosis of the liver ... 531-533, 540-543, 550-553, 560, 574-575	0.64	0.60	0.67	0.67	0.57	0.70	0.77	0.84	0.86	0.90
Cirrhosis of the liver ... 571	0.07	0.0	0.0	0.33	0.34	0.44	0.52	0.57	0.62	0.67
Congenital anomalies and diseases of early infancy ... 740-759, 760-778	0.79	0.88	0.89	0.81	0.80	0.71	0.79	0.81	0.77	0.68
All other diseases ... Remainder of 000-799	0.51	0.79	0.81	0.70	0.58	0.56	0.66	0.72	0.72	0.69
Accidental injuries and other trauma ... E800-E999	0.59	0.65	0.69	0.73	0.63	0.57	0.59	0.68	0.80	0.88
Female										
All causes	0.68	0.69	0.72	0.70	0.67	0.68	0.73	0.78	0.81	0.85
All malignant neoplasms ... 140-209	0.68	0.84	0.90	0.92	0.85	0.81	0.81	0.83	0.85	0.88
Diabetes mellitus ... 250	0.0	0.0	0.0	0.50	0.63	0.64	0.60	0.61	0.65	0.73
Diseases of the heart ... 390-398, 402, 404, 410-429	0.30	0.44	0.50	0.55	0.59	0.64	0.69	0.76	0.80	0.83
Hypertension and stroke ... 400-401, 403, 430-438	0.44	0.43	0.60	0.64	0.74	0.58	0.69	0.75	0.83	0.90
Diseases of the arteries, arterioles, and capillaries ... 440-448	0.50	0.0	0.0	0.50	0.60	0.63	0.74	0.82	0.87	0.94
Acute bronchitis, influenza, and pneumonia ... 466, 470-474, 480-486	0.64	0.56	0.80	0.83	0.64	0.63	0.70	0.74	0.80	0.88
Bronchitis, emphysema, and asthma ... 490-493	0.61	0.25	0.50	0.50	0.60	0.71	0.77	0.80	0.83	0.85
Major digestive diseases, except cirrhosis of the liver ... 531-533, 540-543, 550-553, 560, 574-575	0.68	0.50	0.50	0.33	0.50	0.75	0.71	0.83	0.85	0.91
Cirrhosis of the liver ... 571	0.13	0.0	0.0	0.0	0.29	0.40	0.52	0.57	0.61	0.65
Congenital anomalies and diseases of early infancy ... 740-759, 760-778	0.76	0.84	0.81	0.83	0.75	0.77	0.82	0.80	0.70	0.67
All other diseases ... Remainder of 000-799	0.44	0.74	0.78	0.71	0.67	0.65	0.74	0.80	0.80	0.78
Accidental injuries and other trauma ... E800-E999	0.61	0.64	0.65	0.68	0.62	0.60	0.66	0.74	0.86	0.96

[1] From the National Center for Health Statistics: *Eighth Revision International Classification of Diseases, Adapted for Use in the United States*. PHS Pub. No. 1693. Public Health Service. Washington. U.S. Government Printing Office, 1967.

the rates for the total population, not the white population alone, because the purpose is to show what proportion of the total mortality is considered nonpreventable if one accepts these achievable target death rates as standards.

By and large, the ratios increase with age, as one might expect, since the preventability of a death from most causes drops as one grows older. However, using geographic variability as a gauge of preventability produces some odd and unanticipated results in terms of age. It can be seen in table C, for example, that for all causes of death the lowest ratios for males (and hence, the highest proportion of deaths presumed preventable) occur not in childhood but at the young adult ages. The geographic variability of trauma death rates, which predominate at these ages among the males, may account for this result.

There is also the curious result that the lowest ratios from ages 25 to 85 are seen for cirrhosis of the liver (table C). This rubric, included specifically as an indicator of alcoholism prevalence, showed great geographic variability. While some of this may be a genuine sign that the disease can be prevented, it may also reflect a varying failure in different regions to include mention of this disease on the death certificate. The completeness of reporting cirrhosis of the liver as the underlying cause of death should be studied. If it is still as poorly reported as it was in Westchester County, New York, in 1934,[26] steps should be taken to remedy the situation.

ALTERNATIVE FORMS OF THE INDEX

Desiderata

In using mortality statistics to reflect the health of a jurisdiction, such as a health service area (HSA), it is a practical necessity to have some form of summary index. As pointed out earlier, the display of death rates by age, sex, and cause of death for the jurisdiction's population and comparison of this set with a set of achievable target death rates is too complex for ready comprehension. Furthermore, a summarization is needed in order to reduce effects of random variation.

There is an infinite variety of ways in which such a set of data can be summarized, but the one selected for use must have the following three properties, which limit the choices very substantially:

1. It must be sufficiently easy to compute so that the potential user will not be discouraged by the time and expense of computing it.
2. It must be readily comprehended and must make sense in the context of its use.
3. It must be as "sensitive" as possible, consistent with the other properties.

In this report, "sensitivity" is the degree to which the true, underlying variability in the phenomenon being measured shows up through the "noise" of random variation. The mortality in a particular population during a specified interval of time is a finite sample of deaths produced at that time and place by the underlying forces of mortality characteristic of that population at that time. Every community differs from every other in this characteristic set of underlying mortality forces, and within a community every time period differs from every other one. Of course, the extent of the differences from place to place or time to time may be large or very small. The only way of measuring these differences is to classify and count the particular deaths that express the force of mortality. These deaths are enumerated and classified as completely and accurately as possible, but the particular deaths, though counted completely, can be treated as a random sample because of the very large number of influences determining which persons actually died. It is a sample generated by a set of underlying death rates that represent the mortality "universe" for that time and place.

Note that the concept of sensitivity as the relationship between underlying variability and random variation has nothing to do with the degree to which mortality successfully measures what is thought of as the health of the community. The relevance of mortality to that purpose is assumed, but with certain recognized limitations. It is assumed that some of the deaths from certain causes at certain ages were preventable and, therefore, that estimates of these numbers constitute a measure of correctable failures in the health care system.

Forms of Index Examined and Their Sampling Variability

Four different forms of summary index were examined and examples were calculated. Each index was intended to summarize the mortality of a local population over the whole of the age range for males or females for a cause-of-death group. Thus mortality for the population residing in the area (in this case, an HSA) during a particular period of time (in the examples used, 1969-71) was to be expressed in the form of 24 numbers (12 cause-of-death groups for males and 12 for females) plus "all causes" for males and females.

The notation used in setting down the forms of index is as follows:[d]

A = Subscript for 3-way age classification: under 35 years, 35-64 years, and 65 years and over (coded I, II, III).

a = Subscript for 11-way age classification: under 1 year, 1-4 years, 5-14 years, . . . , 75-84 years, and 85 years and over (coded 1, 2, 3, . . . , 10, 11).

d_A = Number of deaths in the local area (HSA) in the 3-year period 1969-71 in age group A.

d_a = Number of deaths in the local area (HSA) in the 3-year period 1969-71 in age group a.

p_A = Population of the local area (HSA) in 1970 in age group A.

p_a = Population of the local area (HSA) in 1970 in age group a.

P_A = 1970 U.S. population in age group A.

P_a = 1970 U.S. population in age group a.

m_A = Death rate per 100,000 population in the local area (HSA) on an annual basis in age group A in 1969-71.

m_a = Death rate per 100,000 population in the local area (HSA) on an annual basis in age group a in 1969-71.

M_A = Achievable target death rate per 100,000 population in age group A.

M_a = Achievable target death rate per 100,000 population in age group a.

The first form of index examined, called R_i, is defined as:

$$R_i = \sum^{A} \frac{P_A}{\sum P_A} (1 - r_A)$$

in which

$$r_A = \frac{M_A}{m_A} = \frac{M_A (10^{-5}) p_A}{d_A / 3}$$

$$1 - r_A = \frac{d_A - 3(10^{-5}) M_A p_A}{d_A} .$$

The values of M_A are derived from the values of M_a very simply:

$$M_{\mathrm{I}} = \frac{M_1 p_1 + M_2 p_2 + M_3 p_3 + M_4 p_4 + M_5 p_5}{p_{\mathrm{I}}}$$

$$M_{\mathrm{II}} = \frac{M_6 p_6 + M_7 p_7 + M_8 p_8}{p_{\mathrm{II}}}$$

$$M_{\mathrm{III}} = \frac{M_9 p_9 + M_{10} p_{10} + M_{11} p_{11}}{p_{\mathrm{III}}}$$

but

$$M_{11} p_{11} = d_{11}$$

because the achievable target death rate at 85 years and over is considered to be identical to the actual death rate in that local area.

[d] To simplify the notation, subscripts are omitted for the HSA, the sex, and, on the right side of the equation, for the cause-of-death group as well. Hence, in the algebraic expression for the index R_i, population data are assumed to be for a given sex, and death rates or numbers of deaths are assumed to be for the same sex and for the cause-of-death group i.

Note that M_A is almost always less than m_A, so the ratio r_A is almost always less than 1 and, of course, is positive. Hence $1 - r_A$ is almost always positive and less than 1. R can never exceed 1 but may optimally or by chance be negative. A condition that always must be met is $d_A \neq 0$. If d_A should happen to be zero, as occurred in age group I for some causes of death in some of the HSA's used as examples, the age group must be collapsed with a neighboring one and the index computed as a special case.

For additional brevity, write:

$$w_A = \frac{P_A}{\sum P_A} .$$

Hence

$$R_i = \sum^{A} w_A (1 - r_A)$$

and

$$r_A \doteq \frac{(3/10^5) M_A p_A}{d_A}$$

Under certain reasonable assumptions the variance of this weighted sum can be approximated as:

$$\operatorname{var}(R_i) = \sum^{A} \left\{ w_A^2 \operatorname{var}(1 - r_A) \right\}$$

$$= \sum^{A} \left\{ w_A^2 (3/10^5)^2 M_A^2 p_A^2 \operatorname{var}(1/d_A) \right\}.$$

The variable d_A is generated by a process that is essentially Poissonian.[c] Hence the variance of d_A can be taken to be d_A. The variance of $1/d_A$, however, is somewhat more complex. As d_A increases,

$$\operatorname{var}(1/d_A) \to 1/d_A^3 .$$

But for values of d_A less than about 200 deaths, a better approximation is needed. Table 1 (generously calculated for the purposes of this report by Dr. Benjamin J. Tepping) shows the results of a Taylor's series expansion, providing approximations of $E(1/d_A)$ and $\operatorname{var}(1/d_A)$ for values of $E(d_A)$ from 2 to 200.

At $E(d_A) = 200$, the value from the table is:

$$1.2885 \times 10^{-7}$$

as compared with:

$$1.25 \times 10^{-7} \text{ obtained from } 1/200^3 .$$

The form of R_i has certain desirable features, and it was the form initially favored for use with the achievable target death rates. The statistic r_A is the ratio of the deaths that would be expected from a particular cause in age group A in the HSA if the community was to experience the achievable target death rate to the actual number of deaths experienced. It is, thus, the proportion that might be considered nonpreventable. Hence $1 - r_A$ is the proportion of the actual deaths that were preventable, and R_i is a weighted average of these ratios giving weight to each age group in proportion to the fraction of the male or female population in that age group in the entire United States.

As pointed out in an earlier investigation of mortality indexes,[28] the disadvantages of using a "standard population" to weight the age groups are much less serious if the quantities being weighted do not tend to vary greatly from age group to age group, as the age-specific death rates do.

The index R_i is readily understood and makes sense. It is also easily computed, but because of the condition that zeros must not occur in the denominators of the terms, it is necessary to collapse the number of the age groups from the standard 11 to 3.

As will be seen later, however, R_i is heavily penalized by low sensitivity.

[c] Actually, the conditions for a Poissonian variability are only closely met in the generation of d_I values, that is, deaths in the age group under 35 years of age. The variance of the index R_i is dominated, however, by the variance in the youngest age group in all the forms of R_i investigated here. For a single cause-of-death group and sex, the number of deaths under 35 years of age in a 3-year period in a typical HSA is often quite small. For example, in one California area, with a population in 1970 of about 1 million, the value of d_I for males is less than 100 in 9 of the 12 cause groups. In 7 of the groups it is less than 50.

For a discussion of the Poissonian process see Section 3.2 in *Introduction to Stochastic Processes in Biostatistics.*[27]

In the second form of index, called R_i', the statistic r_A is inverted and called r_A'. In other words,

$$r_A' = \frac{1}{r_A} = \frac{d_A}{(3/10^5)M_A p_A}$$

and

$$R_i' = \sum^{A} w_A r_A' \,.$$

In this form, zero values of d_A give no trouble. As noted in table B, certain values of M_a are zero because the deaths from that cause in that age group are considered wholly preventable. However, for the three-group age classification, no zero values of M_A are encountered.

Most of the r_A' values are greater than unity and, of course, all are positive. Hence a value of $R_i' \leqslant 1$ is optimal or a chance event.

Using the same reasonable assumptions as for R_i and again postulating the Poissonian behavior of d_A, we have the following approximate expression for the variance of R_i':

$$\operatorname{var}(R_i') \doteq \sum^{A} \left\{ \frac{w_A^2}{(3/10^5)^2 M_A^2 p_A^2} \, d_A \right\}.$$

Here, the ratios of which a weighted sum forms R_i' are a measure of the relative excess of the actual deaths over the nonpreventable deaths. This is somewhat analogous to the "weighted average of relatives" used in price indexes, the weights being the average proportions of the population experiencing the excess instead of the amounts of that commodity purchased. Also, the form of R_i' seems simple to understand and is very little trouble to compute. Its sensitivity will be considered in the following section.

Both R_i and R_i' have the characteristic that the influence an age group's mortality experience has on the index is roughly proportional to the numbers of persons living in that age group (in the United States, not in the HSA). Conceptually, that seems to be a distinct advantage over other mortality indexes now in common use. In the standardized mortality ratio (SMR) and the comparative mortality figure (CMF)[11] the age group's mortality experience has an influence approximately proportional to the number of deaths occurring at those ages, thus tending to emphasize the older ages—ages at which deaths tend to be much less preventable.

This is an important reason for the alleged lack of sensitivity of mortality measures. It is difficult to bring about improvement of the index by any means within the power of the community to apply.

On the other hand, the ability of the preventable mortality of a local population to show through the "noise" of random variability may not be as great in these weighted sums of ratios. This is the central problem that must be addressed in the construction of a maximally useful index.

The third form of index investigated, called R_i'', is not a weighted sum of ratios but a single ratio in which preventable deaths are summed over all age groups and divided by the sum of actual deaths in the local population for all ages combined. It is expressed as

$$R_i'' = \frac{\sum^{A}\{d_A - (3/10^5)M_A p_A\}}{\sum^{A} d_A}$$

$$= 1 - \left\{ \frac{(3/10^5)\sum^{A} M_A p_A}{\sum^{A} d_A} \right\}.$$

For this index the approximate variance is

$$\operatorname{var}(R_i'') = \frac{(3/10^5)^2 \left(\sum^{A} M_A p_A\right)^2}{\left(\sum^{A} d_A\right)^3} \,.$$

Although the achievable target death rates are relatively closer to actual death rates at the older ages,

$$d_A - (3/10^5)M_A p_A$$

is considerably larger, per year of age, in the older age groups (except that by definition it is zero at ages 85 years and over) than it is at ages under 35 years. Hence, this index suffers from the same disadvantage as the SMR and the CMF. It also has one of the basic disadvantages that is found in the crude death rate: It is not independent of the age distribution of the local area population. HSA's with larger proportions of older people would therefore tend to have higher values of R_i'' for that reason alone. Hence R_i'' was soon dropped from further consideration as a summary index of mortality.

The final version examined was a variant of the ratio R_i'', which, though not independent of the age distribution, gives such heavy weight to the younger ages in comparison to the older ages that only an HSA with a very exceptional age distribution would, by this fact alone, show up with an advantage or disadvantage. This index, called R_i''' here, is based on the same principle as the years of life lost index of mortality that has been described by a number of authors.[29-31] It has been used for comparing the seriousness of causes of death[31] and, for all causes combined, as a measure of the health of counties.[30] There have been a number of variations in the way this years of life lost index has been computed, but it appears that the simplest way gives results that differ in no significant respect from results attained by using more sophisticated methods. The number of deaths in a given age group is multiplied by the difference between the midpoint of that age group and a fixed age that is chosen to represent the end of "productive" life (meaning, it appears, the point at which most individuals cease to contribute to the economy). This product is summed over all age groups for the population whose health is to be measured, and the result is divided by a corresponding figure that is calculated using deaths that would be expected if the death rates had been those of the Nation, or some other standard. The choice of the upper age has differed among different authors. In this report it is taken as 75 years.

For deaths under 1 year of age, therefore, the number of deaths is multiplied by 74.5 to approximate the years of productive life lost by persons dying at that age. In each succeeding age group of the 11 standard groups the multiplier is smaller, until, in the age group 75-84 years, it vanishes. Hence, only deaths at under 75 years of age contribute to the index. Used with the achievable target death rates as the standard, the equation is

$$R_i''' = \frac{\sum^{a} d_a l_a}{\sum^{a} (3/10^5 M_a p_a l_a)}$$

in which

$$l_a = (75 - \text{midpoint of age group } a)$$

The variance is approximated by the following expression:

$$\text{var}(R_i''') = \frac{1}{\left\{\sum^{a} (3/10^5 M_a p_a l_a)\right\}^2} \sum^{a} (d_a l_a)^2 \ .$$

The structure of this index gives a death in the age group under 1 year nearly 15 times the weight that a death in the age group 65-74 years receives. For most causes of death the number of deaths in the latter group outnumber those in infancy by equally large or much larger factors. Consequently, the effects of differences in population distribution tend to be diminished by the weighting system, but the effects of chance variation are increased. The assumption of Poissonian variation in the number of deaths is that the variance increases directly as the number of deaths increases, but the weights attached to the age groups are squared to obtain the variance of the sum.

Since the standard mortality ratio (SMR) index will be used for comparison with the indexes presented in this section, its estimating equation and variance using the same notation and assumptions are shown here.

$$\text{SMR}_i = \frac{\sum^{a} d_a}{3/10^5 \sum^{a} (M_a p_a)}$$

$$\text{var}(\text{SMR}_i) = \frac{\sum^{a} d_a}{\left\{3/10^5 \sum^{a} (M_a p_a)\right\}^2} \ .$$

The customary standard death rates in the SMR are the national death rates. Hence in these equations M_a refers to the 1969-71 U.S. death rate for cause i in age group a, instead of to the corresponding achievable target death rate.

COMPUTING AND TESTING THE INDEXES

For convenient reference in the discussion that follows, the various forms of index examined can be described as follows:

R_i = Weighted average of proportions of actual deaths in each age group considered preventable, using U.S. populations as weights.

R_i' = Weighted average of ratios of actual deaths in each age group to "expected" deaths, that is, deaths considered nonpreventable, using U.S. populations as weights.

R_i'' = Ratio of sum over all ages of deaths considered preventable in each age group to total actual deaths.

R_i''' = Ratio of actual years of life lost to expected years of life lost if only nonpreventable deaths occurred in each age group.

SMR_i = Standardized mortality ratio, that is, ratio of actual deaths at all ages to expected deaths at all ages if U.S. death rates were experienced in each age group.

In each instance, of course, the index is for cause-of-death i and for one or the other of the sex groups.

Health Service Areas Selected for Testing and Computation Methods

In order to illustrate and test the various forms of index, a group of 19 HSA's was selected. This sample was chosen with certain objectives in mind. First and foremost was holding down the expense of aggregating county mortality data for the 3-year period, 1969-71, by cause of death, age, and sex into HSA totals. To accomplish this, a sample of 10 States was chosen to provide geographic variability. HSA's within the States were selected to illustrate highly urban populations and areas with higher proportions of rural and farm populations. Two other considerations were that not too many counties make up the HSA in order to save labor (the numbers of counties ranged from 1 to 14 and totaled 117), and that the HSA not contain too small a population (the 1970 populations ranged from about a half million to 7 million). Table D presents the HSA designation, location, and several demographic characteristics of the 19 HSA's.

The mortality counts for 1969-71 by county for the 10 selected States, classified in the National Center for Health Statistics (NCHS) standard 69-cause recode, and by age, sex, and color were supplied through the NCHS Office of Statistical Research. These counts were keyed and summarized into the HSA totals and the broader cause groups that were used for the achievable target death rates. The keying was carried out by Data Enterprises, Inc., and the programming and computer time were donated by Westat, Inc., both firms in Rockville, Maryland. All index computations were carried out by the author using a handheld programmable calculator; the programs, repeatedly used weights, populations, and death rates were stored on magnetic strips between calculating sessions. Numerical checks on the data entry were built into the programs, but the computations are certainly not completely error free.

For males, R_i, R_i', and R_i''' were computed. Tables 2-5 show the 1969-71 results for each of the 12 cause-of-death groups, and for all causes combined, in the 19 HSA's. Some indexes for males in the United States as a whole are included for comparison (tables 2-4). For females, only R_i''' was computed. Examinations of sensitivity were performed on the indexes for males only.

Table D. Number of population, and percent and number of selected characteristics of 19 health service areas used in the illustrative computations, by selected health service areas

Health service area and location	Population in thousands, 1970	Urban population	Black population	Foreign-born population	Net migration, 1960-70	Labor force in manufacturing	Families below poverty level	Occupied dwelling units without plumbing	Occupied dwelling units with 1.01 or more persons per room	Farm population	Medical doctors per 10,000 population, 1973	Hospital beds per 1,000 population, 1974	Average annual post neonatal mortality per 1,000 live births, 1974-75
	Number	Percent[1]									Number[2]		
California 01:													
Eureka and 14 northern counties	499	44.6	1.0	13.6	2.8	17.6	10.7	2.1	8.0	5.0	6.2	4.3	5.0
California 04:													
San Francisco and nearby counties	1,478	98.3	8.6	36.5	4.7	13.8	6.8	3.8	5.7	0.1	8.9	5.3	4.0
California 09:													
Fresno and 4 central counties	1,043	70.5	4.6	20.6	-0.3	10.0	14.1	1.7	11.1	5.0	4.6	3.5	4.8
California 11:													
Los Angeles	7,032	98.7	10.9	29.0	4.3	27.3	8.2	1.2	8.2	0.0	6.7	4.5	4.4
Connecticut 01:													
Fairfield County	793	86.2	7.1	33.6	10.9	35.1	4.6	2.1	5.5	0.1	6.0	3.5	2.6
Connecticut 04:													
Hartford and Tolland Counties	920	80.0	6.1	32.7	9.4	33.0	4.8	2.1	5.9	0.5	5.2	3.7	3.3
Delaware 01:													
Entire State	548	72.1	14.3	11.7	8.4	29.7	8.3	4.1	5.5	2.1	5.1	3.5	3.7
Florida 06:													
Ft. Myers and 10 southwest counties	591	62.7	12.9	11.4	45.0	10.9	13.8	4.8	7.8	1.3	6.4	5.1	5.9
Florida 09:													
Miami, Dade County, and Monroe County	1,320	97.3	14.7	39.7	25.7	14.5	11.0	2.8	13.2	0.1	7.0	5.4	4.1
Louisiana 01:													
New Orleans and 11 southeast parishes	1,309	83.0	29.3	6.7	6.2	14.5	16.6	4.5	14.3	0.6	4.6	4.6	4.4
Maryland 02:													
Montgomery County	523	89.2	4.1	21.2	37.0	7.3	3.0	1.1	3.1	0.4	9.3	2.2	3.1
Maryland 03:													
Prince Georges County and nearby counties	776	80.7	15.7	11.3	49.1	7.8	5.4	3.2	7.1	1.7	2.8	1.2	3.5
Maryland 04:													
Baltimore and nearby counties	2,071	84.2	23.7	11.3	6.0	25.2	8.5	2.3	6.7	0.9	4.9	4.0	4.2
Michigan 01:													
Detroit and nearby counties	4,778	90.9	16.5	23.3	2.7	36.7	6.5	1.9	7.5	0.6	4.0	4.4	4.9
Michigan 06:													
Saginaw and 14 mid-State counties	690	47.2	4.2	14.3	2.3	35.5	9.0	4.7	8.3	9.6	3.4	4.2	3.8
New Jersey 02:													
Newark (Essex) and 4 northern counties	2,008	92.7	17.4	30.5	4.4	32.9	6.8	2.3	6.2	0.3	5.6	5.0	4.7
Washington 01:													
Seattle and 10 northwest counties	2,145	81.1	2.9	21.0	15.7	23.5	6.2	2.1	4.5	1.3	5.7	3.2	4.7
Wisconsin 01:													
Madison and nearby counties	759	58.7	0.9	12.7	5.3	23.7	6.9	4.6	6.1	13.5	5.2	5.3	4.2
Wisconsin 02:													
Milwaukee and nearby counties	1,756	88.0	6.8	20.6	0.5	36.2	5.7	2.6	6.8	1.6	4.2	4.6	3.8

[1]Data from the U.S. Bureau of the Census: *County and City Data Book, 1977.* All figures are from the 1970 Census.
[2]Data from the Department of Health and Human Services: *Health–United States–1976-1977.*

Tests of Sensitivity

Two measures of sensitivity have been used for comparing different forms of the mortality index. One is the median and range of the coefficient of variation (CV), which are simply the median and range of the ratio of the estimated standard error of the index to the index. The other is a contrived measure consisting of the ratio of the "modified range" among the 19 HSA's to the mean of the the 19 standard errors. Modified range means the difference between the arithmetic averages of the three highest values and the three lowest values of the index. This latter statistic was chosen over alternatives requiring squared differences from the mean of the HSA's because it involves no assumptions about the form of the universe of HSA's from which this nonprobability sample of 19 was drawn, and also because it gives less emphasis to extreme values.[f] The modified range is a measure of the variability as exhibited by these particular local areas, and the mean of the standard errors is intended here as simply a typical estimated standard error.

These parameters were calculated for the entire set of HSA's and for 9 of the 12 cause-of-death groups as well as for all causes. The indexes compared were R_i, R_i', R_i''', and SMR_i (the standard mortality ratio for cause-of-death group i). Table E shows the range and certain rank orders, including the 19-area median, of the coefficient of variation for R_i, R_i', and R_i'''. At this point in the analysis, R_i was dropped from further consideration. There were three reasons for this elimination. First, the zero order correlation coefficients between R_i and R_i' were consistently high, suggesting that these two indexes were measuring the same features of each HSA's mortality. Note the correlation coefficients for the following cause groups for males in the 19 areas:

All malignant neoplasms	.92
Diseases of the heart	.98
Hypertension and stroke	.92
Bronchitis, emphysema, and asthma	.82
Cirrhosis of the liver	.80
Congenital anomalies and diseases of early infancy	.94
Accidental injuries and other trauma	.84
All causes	.97

Second, a comparison of the coefficients of variation of R_i and R_i' for 9 cause groups in the 19 areas showed that in a majority of the paired comparisons the former exceeded the latter (and sometimes by substantial amounts). The following are the results:

Cause-of-death group	$CV(R_i) > CV(R_i')$	$CV(R_i) < CV(R_i')$
All malignant neoplasms	19	0
Diabetes mellitus	12	7
Diseases of the heart	15	4
Hypertension and stroke	14	5
Acute bronchitis, influenza, and pneumonia	5	14
Bronchitis, emphysema, and asthma	8	11
Cirrhosis of the liver	10	9
Congenital anomalies and diseases of early infancy	18	1
Accidental injuries and other trauma	15	4
Total	116	55

Furthermore, the median value of $CV(R_i)$ was greater than the median of $CV(R_i')$ for all the nine cause groups except the two respiratory disease groups, and the range was greater in every group. (See table E.)

A third reason for eliminating R_i from the comparisons was that, despite consolidation from 11 age groups to 3 and the use of mortality

[f] A more direct measure of underlying geographic variability, which does require the squaring of differences from the mean, is provided by the geographic component of variance. This is the method used by Kleinman et al. in analyzing infant mortality rates.[32] For comparison, the square root of the geographic component of variance was also computed for the 9 causes of death in the 19 HSA's. The zero-order correlation between this and the modified range was extremely high.

Table E. Selected rank orders and range of coefficients of variation (CV) for three forms of mortality index (R_i, R_i', and R_i''') for males, by cause-of-death group: 19 health service areas, 1969-71

Cause-of-death group and coefficient of variation	5th rank	10th rank	15th rank	Range
All malignant neoplasms:				
$CV(R_i)$	0.148	0.201	0.290	0.364
$CV(R_i')$	0.049	0.066	0.082	0.072
$CV(R_i''')$	0.021	0.031	0.038	0.037
Diabetes mellitus:				
$CV(R_i)$	0.192	0.310	0.721	1.71
$CV(R_i')$	0.177	0.268	0.311	0.362
$CV(R_i''')$	0.072	0.113	0.124	0.163
Diseases of the heart:				
$CV(R_i)$	0.069	0.229	0.345	1.28
$CV(R_i')$	0.070	0.105	0.126	0.119
$CV(R_i''')$	0.015	0.021	0.025	0.025
Hypertension and stroke:				
$CV(R_i)$	0.101	0.220	0.368	1.62
$CV(R_i')$	0.102	0.150	0.186	0.177
$CV(R_i''')$	0.038	0.053	0.069	0.077
Acute bronchitis, influenza, and pneumonia:				
$CV(R_i)$	0.027	0.045	0.089	0.237
$CV(R_i')$	0.064	0.081	0.106	0.116
$CV(R_i''')$	0.059	0.077	0.104	0.107
Bronchitis, emphysema, and asthma:				
$CV(R_i)$	0.107	0.191	0.722	18.13
$CV(R_i')$	0.202	0.295	0.363	0.384
$CV(R_i''')$	0.068	0.080	0.107	0.125
Cirrhosis of the liver:				
$CV(R_i)$	0.038	0.236	0.750	8.57
$CV(R_i')$	0.130	0.196	0.317	0.295
$CV(R_i''')$	0.044	0.060	0.089	0.099
Congenital anomalies and diseases of early infancy:				
$CV(R_i)$	0.109	0.291	0.494	2.12
$CV(R_i')$	0.075	0.103	0.137	0.119
$CV(R_i''')$	0.033	0.047	0.057	0.059
Accidental injuries and other trauma:				
$CV(R_i)$	0.021	0.037	0.079	1.53
$CV(R_i')$	0.019	0.022	0.032	0.036
$CV(R_i''')$	0.022	0.025	0.036	0.041

statistics for a period of 3 years combined, there were instances when the actual number of deaths for a cause group in the age group "under 35 years" was zero. This happened in only one of the 19 areas for 2 of the cause-of-death groups, but since d_A appears in the denominator of R_i, the zero values had to be ruled out. This was done in those two instances by computing the ratio for all ages combined, omitting the standard population weighting. However, in a number of other age-cause cells there was only a single death in the 3-year period, which led to extreme values of the estimated variance of both R_i and R_i'.

By this process of elimination there is left only the comparison of the sensitivity among R_i', R_i''', and SMR_i, using the second measure of sensitivity described earlier, the ratio of the modified range to the mean standard error. This comparison is presented in table F.

By and large the modified range of both R_i' and R_i''' is larger than that of the SMR_i for the same cause group. For seven of the nine cause-of-death groups, not counting all causes combined, the modified range of R_i' is the largest and the spread of the SMR_i index is the smallest. However, the mean standard error is consistently lowest for the SMR_i and, almost without exception, is lower for R_i''' than it is for R_i'. Hence, if the ratio of the former quantity to the latter is taken as the indicator of the extent to which the information contained in the index shows

Table F. Highest and lowest value, modified range (MR), mean standard error ($\bar{s}_j$) and ratio for three forms of mortality index (R'_j, R'''_j, and SMR_j) for males, by cause-of-death group: 19 health service areas, 1969-71

Highest and lowest value, modified range (MR), mean standard error (s_j)	All causes	All malignant neoplasms	Diabetes mellitus	Diseases of the heart	Hyper-tension and stroke	Acute bronchitis, influenza, and pneumonia	Bronchitis, emphysema, and asthma	Cirrhosis of the liver	Congenital anomalies and diseases of early infancy	Accidental injuries and other trauma
Highest value:										
R'_j	2.128	1.474	3.526	2.305	3.442	3.936	6.929	6.095	2.131	2.725
R'''_j	2.017	1.570	3.241	1.867	3.061	3.844	3.621	4.785	2.212	2.878
SMR_j	1.199	1.251	1.783	1.202	1.169	1.112	1.587	2.262	1.234	1.447
Lowest value:										
R'_j	1.143	1.181	1.218	1.172	1.428	1.554	0.434	1.125	1.108	1.048
R'''_j	1.117	1.044	1.128	1.077	1.320	1.570	0.930	1.122	1.292	1.018
SMR_j	0.783	0.870	0.668	0.792	0.705	0.619	0.686	0.571	0.725	0.625
Modified range:										
R'_j	0.710	0.254	1.845	0.919	1.179	2.012	4.656	3.927	0.776	1.432
R'''_j	0.669	0.411	1.605	0.560	0.966	1.818	2.113	2.644	0.732	1.510
SMR_j	0.280	0.328	0.955	0.348	0.333	0.386	0.650	1.125	0.415	0.753
$\bar{s}_j$:										
R'_j	0.022	0.087	0.516	0.148	0.268	0.219	0.728	0.515	0.159	0.042
R'''_j	0.020	0.035	0.188	0.027	0.092	0.202	0.180	0.138	0.076	0.046
SMR_j	0.008	0.019	0.066	0.012	0.025	0.041	0.052	0.058	0.043	0.023
Ratio MR/$\bar{s}_j$:										
R'_j	32.3	2.9	3.6	6.2	4.4	9.2	6.4	7.6	4.9	34.1
R'''_j	33.5	11.7	8.5	20.7	10.5	9.0	11.7	19.2	9.6	32.8
SMR_j	35.0	17.3	14.5	29.0	13.3	9.4	12.5	19.4	9.7	32.7

through the noise of random variation, the standardized mortality ratio form of mortality index is, for most cause groups, the most sensitive of the three forms compared, though the indicator is only slightly better for five of the nine independent groups and slightly poorer for a sixth group.

For all causes combined, the modified range of the SMR_j values in the 19 HSA's is 35 times the typical standard error; for the index based on years of life lost it is 33½ times the typical standard error.

Conclusions

From these results the following conclusions can be drawn:

1. Indexes in the form of weighted averages of ratios for individual age groups have inherent advantages, namely, the weighting of excess mortality according to the approximate proportions of the population experiencing the excess, the expression of excesses in a form that is independent of the numbers of deaths at the ages at which they occur, and an apparent greater range of magnitude in the values from one HSA to another as compared with other commonly used indexes. However, the random variation of the weighted averages of ratios, at least those forms included in this experiment, is sufficiently higher than that of the other forms that the underlying area-to-area differences in mortality by cause of death in a 3-year period may be obscured.

2. As an alternative for use with an index in which achievable target death rates by cause of death, age, and sex are used as the standard, the years of life lost form has nearly as high a sensitivity as the older single-ratio form of index in which the total of actual deaths is divided by the computed expected number, assuming the standard mortality is experienced. The years of life lost form has the conceptual advantage that mortality at the younger ages, considered much more amenable to correction efforts, is weighted a great deal more than is mortality at advanced ages.

FUTURE RESEARCH

Improvement of the Achievable Target Death Rates

Some areas of needed improvement in constructing the set of death rates used as achievable targets in this report have already been pointed out. The principal question remaining is the soundness of the underlying assumption that the lowest achieved mortality in some part of the United States is a reasonable basis for achievable target death rates as that concept has been defined here. Can all deaths measured by death rates as in excess of these justifiably be labeled "preventable"? Or do these lowest achieved rates understate what modern medical science and an optimum health care system could bring about? If geographic variability is to be used as the basis for the standard, as Guralnick and Jackson suggested,[24] how should it be analyzed? Some preliminary work done during the course of this project suggests that using the lowest State rate rather than the lowest geographic division rate might have produced quite different results. It has also been suggested that the mortality in the HSA that exhibited the lowest death rates for a particular cause should be used as the standard.

Of greatest value, it seems, in arriving at a tenable target set of rates would be the further use of the type of expert judgment that Rutstein and the members of the Working Group on Preventable and Manageable Diseases, and the scientists called upon by the Public Services Laboratory of Georgetown University,[19-21] have brought to bear. However, such judgment should be directed specifically to the question of the proportion of present mortality as recorded by cause of death, age, and sex that could be prevented given optimal circumstances.

It is quite possible that small differences in the values used for the target set of death rates would have little effect on the relative differences in the index for a particular cause-of-death category among the HSA's. The sensitivity of such comparisons to changes in the achievable target death rates deserves further investigation.

Nevertheless, if the premises set forth in the introduction to this report are correct, and if mortality by cause of death can be used to measure the health of local area populations, such as HSA's, then the development of a widely accepted set of achievable target death rates can prove extremely useful for measuring community health and, hence, for health planning.

The Form of Indexes and Their Random Variability

Variation in death rates from area to area can be thought of as originating partly from differences in the underlying forces of mortality, which are largely a product of health conditions in the population, and partly from differences that could be expected to occur if one were able to repeat many times the experience of the identical set of forces acting on the identical set of people during the same period of time. The usefulness of small-area mortality indexes depends heavily upon one's ability to determine the general magnitude of the latter, that is, the random component of variability so that the former component can be estimated.

The estimation of sampling error for these indexes is based upon the theoretical work done by Chiang[27,33] and others, plus some simplifying assumptions that are justified but that tend to overestimate the sampling error slightly. For the purpose of comparing the usefulness of different algebraic forms of an index number, the crude methods used here would lead to no different conclusions than more sophisticated estimates. Nevertheless, it would provide a sounder basis for evaluating the indexes and computing confidence intervals if real experiments of the Monte Carlo type[g] could be conducted using computer simulation of the process by which the deaths occur.

Geographic Variability

A further question in examining the data by cause of death for these 19 areas is: What is the

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[g] A Monte Carlo type experiment is an experiment in which one attempts to duplicate the chance variation occurring in nature by generating random numbers, usually on a computer, in order to repeat artificially a phenomenon that does not repeat itself under identical conditions in nature.

significance of the apparently wide differences in the amount of geographic variability exhibited by indexes for different cause-of-death groups? Already the National Cancer Institute of the National Institutes of Health has made wide use of the leads presented by county-to-county differences in 10-year summaries of cancer mortality. The leads are systematically being followed up by planning pointed epidemiological studies to test hypotheses. Yet the data presented in this report suggest that a number of other causes have wider underlying geographic variability than cancer does.

"Market Testing" Mortality Indexes for Health Service Areas

The most direct method of determining whether indexes of the type presented here can be useful to planning staffs in the HSA's is to make the statistics available to the HSA's and work with the Bureau of Health Planning in the Health Resources Administration, Public Health Service, to investigate the use made of those statistics, along with more commonly used indexes, such as infant mortality, in setting goals and guiding efforts.

If this is to be done, NCHS should routinely tabulate 5-year aggregations of deaths by cause, age, sex, and color for each HSA for the periods centering on the years of the decennial and mid-decade censuses. Although the 3-year aggregations used in this report can yield usefully precise measures for most HSA's, small numbers are still a problem. Health conditions do not change so rapidly from one 5-year period to the next that the value of 5-year averages is destroyed. Increasing the numbers of deaths on which the HSA index is based by a factor of 5/3 reduces the typical standard error, and, therefore, the width of the confidence interval by a factor of roughly 22½ percent, a highly worthwhile gain.

The start in 1985 of what are hoped to be regular mid-decade censuses, or, at least, large sample surveys that will make possible improved estimates of populations by county, age, race, and sex, makes this an opportune time to consider a program of 5-year summaries of deaths by cause to facilitate the measurement of health for areas smaller than States.

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LIST OF DETAILED TABLES

Table 1. Results of a Taylor's series expansion: $E(1/d_A)$ and var $(1/d_A)$ for $2 \leqslant d_A \leqslant 200$, assuming Poissonian distribution

[Courtesy of Benjamin J. Tepping]

d_A	$E(1/d_A)$	$\mathrm{var}(1/d_A)$		d_A	$E(1/d_A)$	$\mathrm{var}(1/d_A)$	
		Mantissa	Exponent			Mantissa	Exponent
2	0.57659	9.0702	−2	31	0.03337	4.1559	−5
3	0.43268	7.2527	−2	32	0.03229	3.7505	−5
4	0.32963	4.9112	−2	33	0.03128	3.3962	−5
5	0.25777	3.0481	−2	34	0.03033	3.0853	−5
6	0.20779	1.8168	−2	35	0.02944	2.8112	−5
7	0.17249	1.0734	−2	36	0.02860	2.5688	−5
8	0.14689	6.4325	−3	37	0.02780	2.3535	−5
9	0.12776	3.9705	−3	38	0.02705	2.1616	−5
10	0.11302	2.5484	−3	39	0.02634	1.9901	−5
11	0.10135	1.7067	−3	40	0.02566	1.8363	−5
12	0.09190	1.1916	−3	45	0.02274	1.2651	−5
13	0.08407	8.6398	−4	50	0.02042	9.0844	−6
14	0.07749	6.4720	−4	55	0.01853	6.7424	−6
15	0.07187	4.9834	−4	60	0.01695	5.1414	−6
16	0.06702	3.9263	−4	65	0.01563	4.0098	−6
17	0.06279	3.1534	−4	70	0.01450	3.1875	−6
18	0.05906	2.5739	−4	80	0.01266	2.1108	−6
19	0.05575	2.1301	−4	90	0.01124	1.4693	−6
20	0.05280	1.7839	−4	100	0.01010	1.0636	−6
21	0.05014	1.5095	−4	110	0.00918	7.9453	−7
22	0.04774	1.2891	−4	120	0.00840	6.0907	−7
23	0.04556	1.1100	−4	130	0.00775	4.7713	−7
24	0.04357	9.6275	−5	140	0.00719	3.8071	−7
25	0.04175	8.4056	−5	150	0.00671	3.0861	−7
26	0.04007	7.3831	−5	160	0.00629	2.5363	−7
27	0.03852	6.5206	−5	170	0.00592	2.1097	−7
28	0.03709	5.7878	−5	180	0.00559	1.7736	−7
29	0.03576	5.1612	−5	190	0.00529	1.5053	−7
30	0.03453	4.6222	−5	200	0.00503	1.2885	−7

Table 2. Values of mortality index R_i for males, using achievable target death rates as standard, for 12 cause-of-death groups and all causes: United States and 19 health service areas, 1969-71, and United States, 1976

[Standard error (s_i) shown for certain cause-of-death groups]

Cause-of-death group, R_i, and s_i	United States, 1969-71	United States, 1976	Health service areas, 1969-71					
			California				Connecticut	
			01	04	09	11	01	04
All causes:								
R_i	0.3703	0.2725	0.4108	0.3370	0.4039	0.3495	0.2264	0.2259
s_i	---	---	0.011	0.008	0.007	0.003	0.015	0.014
All malignant neoplasms:								
R_i	0.2329	0.1322	0.2641	0.2524	0.1973	0.2560	0.2670	0.1840
s_i	---	---	0.060	0.037	0.045	0.015	0.048	0.058
Diabetes mellitus:								
R_i	0.5414	0.4350	0.5169	0.3436	0.4571	0.3584	0.4668	0.3984
s_i	---	---	0.109	0.192	0.240	0.069	0.276	0.287
Diseases of the heart:								
R_i	0.4089	0.3264	0.1547	0.1992	0.2414	0.3358	0.2629	0.2856
s_i	---	---	0.207	0.069	0.079	0.021	0.087	0.065
Hypertension and stroke:								
R_i	0.5037	0.3501	0.4475	0.3516	0.4617	0.3739	0.3818	0.3756
s_i	---	---	0.165	0.098	0.063	0.038	0.165	0.115
Diseases of the arteries, arterioles, and capillaries:								
R_i	0.3910	0.3797	0.5028	0.1394	0.1444	0.3698	−0.0594	0.1652
s_i	---	---	---	---	---	---	---	---
Acute bronchitis, influenza, and pneumonia:								
R_i	0.5411	0.3007	0.6300	0.6493	0.5945	0.5513	0.5437	0.4447
s_i	---	---	0.033	0.016	0.024	0.011	0.038	0.060
Bronchitis, emphysema, and asthma:								
R_i	0.6568	0.4416	0.7252	0.5762	0.7967	0.5942	−0.0397	0.4502
s_i	---	---	0.125	0.092	0.021	0.030	0.721	0.247
Major digestive diseases, except cirrhosis of the liver:								
R_i	0.5608	0.3021	0.3939	0.5370	0.5504	0.4554	0.4155	0.3540
s_i	---	---	---	---	---	---	---	---
Cirrhosis of the liver:								
R_i	0.6246	0.6230	−0.1615	0.7716	0.6823	0.7437	0.5212	0.5868
s_i	---	---	0.948	0.029	0.072	0.011	0.256	0.156
Congenital anomalies and diseases of early infancy:								
R_i	0.3645	0.1869	0.1477	0.2495	0.4366	0.3582	0.3259	0.3467
s_i	---	---	0.325	0.096	0.083	0.028	0.161	0.115
All other diseases:								
R_i	0.3805	0.3060	0.1163	0.1412	0.1648	0.0809	0.1926	0.3014
s_i	---	---	---	---	---	---	---	---
Accidental injuries and other trauma:								
R_i	0.4144	0.3271	0.5917	0.4561	0.5654	0.4230	0.0908	0.0940
s_i	---	---	0.012	0.011	0.009	0.005	0.033	0.030

[1] Not adjusted to U.S. age distribution.

NOTE: In everyday use for health planning, only two significant figures should be carried.

Table 2. Values of mortality index R_i for males, using achievable target death rates as standard, for 12 cause-of-death groups and all causes: United States and 19 health service areas, 1969-71, and United States, 1976—Con.

[Standard error (s_i) shown for certain cause-of-death groups]

Health service areas, 1969-71												
Delaware	Florida		Louisiana	Maryland			Michigan		New Jersey	Washington	Wisconsin	
01	06	09	01	02	03	04	01	06	02	01	01	02
0.3751	0.4958	0.4031	0.4899	0.1214	0.3026	0.4271	0.3877	0.3468	0.3722	0.2869	0.2291	0.2419
0.013	0.007	0.007	0.006	0.021	0.012	0.006	0.004	0.011	0.006	0.007	0.014	0.010
0.2271	0.2266	0.2113	0.2315	0.2501	0.3187	0.2493	0.2849	0.2718	0.2448	0.1745	0.1374	0.1535
0.078	0.077	0.052	0.053	0.048	0.042	0.038	0.019	0.048	0.036	0.035	0.058	0.045
0.6725	0.3364	0.3047	0.6485	0.1616	0.4731	0.5549	0.6238	0.2163	0.5802	0.5278	0.5621	0.4801
0.132	0.247	0.363	0.114	0.288	0.241	0.108	0.042	0.350	0.060	0.059	0.146	0.149
0.3875	0.4203	0.3789	0.5452	0.1965	0.1636	0.4915	0.3620	0.2961	0.4742	0.2067	0.1426	0.3557
0.089	0.058	0.043	0.025	0.125	0.120	0.023	0.025	0.095	0.027	0.059	0.136	0.042
0.3134	0.5540	0.3942	0.6886	0.3494	0.4387	0.5330	0.5130	0.2402	0.4909	0.4280	0.3943	0.4187
0.321	0.109	0.094	0.024	0.183	0.097	0.041	0.029	0.399	0.048	0.056	0.131	0.082
0.0962	0.6329	0.0684	0.2640	0.4214	0.5508	0.2798	0.3539	-0.0335	0.0107	-0.1498	-0.3421	0.3208
---	---	---	---	---	---	---	---	---	---	---	---	---
0.6130	0.6583	0.5955	0.6662	0.3971	0.4716	0.5636	0.5975	0.4962	0.6063	0.4319	0.2937	0.5348
0.034	0.022	0.026	0.015	0.083	0.055	0.023	0.011	0.044	0.016	0.038	0.075	0.024
0.7321	0.6861	0.4235	0.7276	[1]0.2339	0.6114	0.5516	0.7004	0.0979	0.4439	0.6307	-0.0254	0.2947
0.078	0.131	0.306	0.033	0.025	0.170	0.017	0.248	0.720	0.196	0.079	0.079	0.383
0.5233	0.3822	0.3515	0.6650	0.2610	0.3316	0.5609	0.5373	0.4725	0.5434	0.4794	0.5569	0.4205
---	---	---	---	---	---	---	---	---	---	---	---	---
0.6523	0.5575	0.5248	0.6299	0.4198	0.4028	0.7785	0.7667	0.4017	0.7104	0.4650	0.3022	-0.0891
0.120	0.132	0.195	0.049	0.243	0.371	0.012	0.010	0.301	0.018	0.098	0.282	0.764
0.3366	0.4410	0.5210	0.5042	[1]0.2196	0.2841	0.3385	0.4087	0.2271	0.3495	0.3800	0.3178	0.4022
0.222	0.191	0.044	0.073	0.018	0.189	0.099	0.038	0.315	0.089	0.050	0.108	0.044
0.2454	0.5220	0.3959	0.4593	0.0857	0.3056	0.5551	0.3611	0.0914	0.3631	0.2728	0.0987	0.0742
---	---	---	---	---	---	---	---	---	---	---	---	---
0.3842	0.6066	0.4750	0.5216	0.0302	0.2954	0.3982	0.3813	0.3999	0.2705	0.3364	0.2884	0.2039
0.022	0.010	0.011	0.010	0.046	0.023	0.011	0.010	0.018	0.015	0.012	0.023	0.019

Table 3. Values of mortality index R_i' for males, using achievable target death rates as standard, for 12 cause-of-death groups and all causes: United States and 19 health service areas, 1969-71, and United States, 1976

[Standard error (s_i') shown for certain cause-of-death groups]

Cause-of-death group, R_i', and s_i'	United States, 1969-71	United States, 1976	Health service areas, 1969-71			
			California			
			01	04	09	11
All causes:						
R_i'	1.6039	1.3835	1.743	1.517	1.732	1.555
s_i'	---	---	0.039	0.021	0.026	0.009
All malignant neoplasms:						
R_i'	1.3295	1.1636	1.395	1.343	1.276	1.370
s_i'	---	---	0.137	0.074	0.087	0.035
Diabetes mellitus:						
R_i'	2.2287	1.8184	3.526	1.571	1.872	1.562
s_i'	---	---	1.169	0.360	0.502	0.163
Diseases of the heart:						
R_i'	1.7273	1.5571	1.192	1.251	1.323	1.525
s_i'	---	---	0.185	0.108	0.139	0.057
Hypertension and stroke:						
R_i'	2.0757	1.5613	1.857	1.549	1.987	1.601
s_i'	---	---	0.418	0.199	0.299	0.093
Diseases of the arteries, arterioles, and capillaries:						
R_i'	1.6715	1.7001	2.075	1.185	1.199	1.625
s_i'	---	---	0.989	0.368	0.447	0.222
Acute bronchitis, influenza, and pneumonia:						
R_i'	2.3040	1.4491	3.015	3.339	2.859	3.529
s_i'	---	---	0.358	0.223	0.231	0.105
Bronchitis, emphysema, and asthma:						
R_i'	3.5108	2.0920	3.728	2.865	6.929	2.751
s_i'	---	---	1.355	0.754	1.400	0.322
Major digestive diseases, except cirrhosis of the liver:						
R_i'	2.3999	1.4563	1.650	2.181	2.235	1.849
s_i'	---	---	0.494	0.347	0.388	0.137
Cirrhosis of the liver:						
R_i'	2.9339	2.9862	1.148	4.437	3.192	4.142
s_i'	---	---	0.385	0.519	0.607	0.258
Congenital anomalies and diseases of early infancy:						
R_i'	1.6028	1.2367	1.290	1.378	1.795	1.559
s_i'	---	---	0.185	0.130	0.184	0.063
All other diseases:						
R_i'	1.6519	1.4669	1.151	1.166	1.202	1.090
s_i'	---	---	0.090	0.050	0.059	0.022
Accidental injuries and other trauma:						
R_i'	1.7347	1.5030	2.495	1.877	2.330	1.739
s_i'	---	---	0.074	0.036	0.050	0.016

NOTE: In everyday use for health planning, only three significant figures should be carried.

Table 3. Values of mortality index R_i' for males, using achievable target death rates as standard, for 12 cause-of-death groups and all causes: United States and 19 health service areas, 1969-71, and United States, 1976—Con.

[Standard error (s_i') shown for certain cause-of-death groups]

Health service areas, 1969-71														
Connecticut		Delaware	Florida		Louisiana	Maryland			Michigan		New Jersey	Washington	Wisconsin	
01	04	01	06	09	01	02	03	04	01	06	02	01	01	02
1.294	1.294	1.604	2.128	1.715	1.978	1.143	1.437	1.755	1.646	1.544	1.608	1.405	1.301	1.320
0.027	0.024	0.033	0.043	0.025	0.024	0.030	0.024	0.018	0.012	0.029	0.019	0.016	0.025	0.017
1.395	1.227	1.300	1.302	1.276	1.336	1.472	1.474	1.347	1.404	1.402	1.326	1.218	1.189	1.181
0.110	0.089	0.113	0.125	0.078	0.071	0.140	0.098	0.058	0.042	0.112	0.065	0.057	0.097	0.063
1.877	1.686	3.189	1.542	1.439	2.885	1.218	1.924	2.262	2.664	1.407	2.580	2.334	2.498	1.938
0.584	0.496	0.914	0.629	0.393	0.510	0.563	0.505	0.360	0.266	0.448	0.458	0.388	0.698	0.391
1.377	1.443	1.634	1.881	1.684	2.305	1.265	1.213	2.044	1.582	1.422	1.984	1.261	1.172	1.578
0.175	0.160	0.206	0.263	0.156	0.171	0.197	0.127	0.128	0.072	0.174	0.133	0.088	0.142	0.122
1.628	1.624	1.489	2.338	1.691	3.442	1.612	1.798	2.222	2.090	1.428	2.021	1.761	1.663	1.741
0.303	0.276	0.312	0.457	0.246	0.341	0.379	0.281	0.212	0.135	0.252	0.218	0.179	0.297	0.196
1.040	1.201	1.133	4.113	1.145	1.418	1.808	2.396	1.407	1.612	1.054	1.047	0.959	0.764	1.487
0.461	0.510	0.592	1.561	0.401	0.435	0.896	0.775	0.357	0.277	0.480	0.311	0.247	0.414	0.433
2.368	1.830	2.922	3.936	2.718	3.651	1.721	1.920	2.402	2.819	2.670	2.995	1.804	1.554	2.671
0.252	0.184	0.322	0.406	0.209	0.232	0.252	0.190	0.146	0.107	0.278	0.179	0.117	0.197	0.180
1.003	1.838	4.758	3.398	1.800	4.868	0.434	2.688	2.319	4.046	1.403	1.897	2.808	1.149	1.418
0.503	0.687	1.567	1.287	0.553	1.022	0.067	0.839	0.530	0.486	0.508	0.509	0.554	0.461	0.419
1.779	1.555	2.129	1.690	1.665	3.044	1.489	1.605	2.296	2.188	2.029	2.211	1.948	2.307	1.742
0.442	0.350	0.525	0.453	0.293	0.395	0.497	0.322	0.281	0.175	0.407	0.290	0.254	0.452	0.261
2.091	2.427	3.100	2.858	2.149	3.105	1.865	1.789	6.095	5.040	1.679	4.469	1.877	1.549	1.125
0.552	0.528	0.834	0.920	0.422	0.560	0.665	0.385	0.646	0.382	0.533	0.582	0.296	0.504	0.211
1.499	1.556	1.557	1.888	2.131	2.086	1.108	1.537	1.557	1.707	1.406	1.616	1.627	1.595	1.716
0.171	0.171	0.218	0.204	0.170	0.183	0.176	0.211	0.111	0.079	0.170	0.103	0.122	0.218	0.145
1.241	1.446	1.327	2.221	1.697	1.874	1.161	1.443	2.323	1.616	1.105	1.655	1.392	1.116	1.081
0.073	0.072	0.085	0.115	0.070	0.065	0.090	0.070	0.062	0.033	0.068	0.055	0.045	0.067	0.044
1.100	1.105	1.652	2.725	1.960	2.123	1.048	1.467	1.696	1.628	1.674	1.373	1.542	1.421	1.274
0.040	0.036	0.057	0.078	0.042	0.043	0.047	0.046	0.030	0.019	0.052	0.028	0.027	0.045	0.028

Table 4. Values of mortality index R_i''' for males, using achievable target death rates as standard, for 12 cause-of-death groups and all causes: United States and 19 health service areas, 1969-71, and United States, 1976

[Standard error (s_i''') shown for certain cause-of-death groups]

Cause-of-death group, R_i''', and s_i'''	United States, 1969-71	United States, 1976	Health service areas, 1969-71			
			California			
			01	04	09	11
All causes:						
R_i'''	1.614	1.367	1.651	1.512	1.660	1.533
s_i'''	---	---	0.029	0.016	0.021	0.008
All malignant neoplasms:						
R_i'''	1.246	1.221	1.212	1.271	1.113	1.221
s_i'''	---	---	0.047	0.028	0.035	0.014
Diabetes mellitus:						
R_i'''	1.972	1.524	1.530	1.339	1.751	1.571
s_i'''	---	---	0.270	0.130	0.197	0.069
Diseases of the heart:						
R_i'''	1.457	1.229	1.321	1.208	1.253	1.366
s_i'''	---	---	0.034	0.020	0.026	0.011
Hypertension and stroke:						
R_i'''	2.020	1.460	1.531	1.599	1.564	1.678
s_i'''	---	---	0.109	0.070	0.093	0.035
Diseases of the arteries, arterioles, and capillaries:						
R_i'''	1.428	1.229	1.755	1.366	1.423	1.440
s_i'''	---	---	0.184	0.096	0.130	0.053
Acute bronchitis, influenza, and pneumonia:						
R_i'''	2.929	1.494	2.908	3.230	2.821	3.474
s_i'''	---	---	0.302	0.192	0.218	0.100
Bronchitis, emphysema, and asthma:						
R_i'''	2.281	1.343	3.462	1.692	3.621	2.001
s_i'''	---	---	0.277	0.131	0.286	0.074
Major digestive diseases, except cirrhosis of the liver:						
R_i'''	2.059	1.366	1.823	2.068	2.197	1.803
s_i'''	---	---	0.331	0.216	0.285	0.099
Cirrhosis of the liver:						
R_i'''	2.121	2.004	1.964	4.785	2.930	3.307
s_i'''	---	---	0.175	0.165	0.166	0.067
Congenital anomalies and diseases of early infancy:						
R_i'''	1.774	1.262	1.466	1.308	1.739	1.566
s_i'''	---	---	0.111	0.062	0.077	0.028
All other diseases:						
R_i'''	1.593	1.567	1.109	1.174	1.207	1.102
s_i'''	---	---	0.076	0.043	0.055	0.020
Accidental injuries and other trauma:						
R_i'''	1.697	1.496	2.542	1.838	2.334	1.747
s_i'''	---	---	0.084	0.040	0.055	0.018

NOTE: In everyday use for health planning, only three significant figures should be carried.

Table 4. Values of mortality index R_i''' for males, using achievable target death rates as standard, for 12 cause-of-death groups and all causes: United States and 19 health service areas, 1969-71, and United States, 1976—Con.

[Standard error (s_i''') shown for certain cause-of-death groups]

Health service areas, 1969-71														
Connecticut		Dela-ware	Florida		Loui-siana	Maryland			Michigan		New Jersey	Wash-ington	Wisconsin	
01	04	01	06	09	01	02	03	04	01	06	02	01	01	02
1.285	1.308	1.646	1.896	1.659	2.017	1.117	1.477	1.801	1.655	1.520	1.591	1.419	1.304	1.350
0.020	0.020	0.029	0.028	0.018	0.021	0.025	0.025	0.015	0.010	0.025	0.015	0.014	0.022	0.014
1.208	1.202	1.378	1.255	1.338	1.570	1.074	1.393	1.502	1.346	1.234	1.304	1.138	1.044	1.178
0.040	0.037	0.053	0.040	0.030	0.037	0.052	0.053	0.027	0.018	0.046	0.025	0.024	0.041	0.026
1.764	1.645	2.650	1.581	1.401	3.241	1.128	1.684	2.572	2.793	1.792	1.913	1.870	1.864	1.815
0.200	0.194	0.328	0.196	0.129	0.231	0.228	0.241	0.159	0.109	0.218	0.138	0.147	0.242	0.142
1.192	1.187	1.672	1.296	1.329	1.867	1.077	1.426	1.665	1.456	1.417	1.604	1.302	1.290	1.381
0.028	0.027	0.043	0.029	0.022	0.031	0.036	0.040	0.022	0.014	0.035	0.021	0.019	0.031	0.021
1.557	1.479	1.762	1.928	1.565	3.061	1.320	1.787	2.176	2.070	1.872	1.842	1.733	1.572	1.900
0.096	0.093	0.139	0.102	0.072	0.126	0.130	0.137	0.077	0.050	0.112	0.068	0.066	0.108	0.073
1.423	1.276	1.332	1.685	1.340	1.722	1.349	1.969	1.591	1.323	1.472	1.318	1.349	0.891	1.421
0.143	0.138	0.165	0.154	0.098	0.139	0.186	0.254	0.100	0.063	0.163	0.089	0.087	0.106	0.100
2.336	1.898	2.983	3.371	2.710	3.844	1.767	2.012	2.490	2.803	2.649	2.902	1.926	1.570	2.614
0.224	0.174	0.318	0.301	0.175	0.236	0.241	0.211	0.137	0.099	0.271	0.157	0.116	0.192	0.168
1.194	1.701	2.796	2.664	2.035	2.860	0.930	2.226	1.969	2.475	2.113	1.557	2.420	1.624	1.481
0.131	0.177	0.323	0.218	0.138	0.238	0.151	0.297	0.130	0.103	0.213	0.109	0.142	0.173	0.109
1.492	1.511	2.109	1.819	1.881	2.912	1.172	1.618	2.356	2.234	2.038	2.131	1.883	2.220	1.826
0.262	0.252	0.401	0.278	0.201	0.299	0.322	0.293	0.202	0.132	0.295	0.191	0.189	0.335	0.192
2.164	2.461	2.417	1.657	2.578	2.379	1.301	2.338	3.674	3.391	1.496	2.378	1.778	1.122	1.668
0.149	0.156	0.207	0.153	0.129	0.142	0.155	0.185	0.136	0.086	0.144	0.105	0.088	0.123	0.091
1.537	1.577	1.753	2.212	2.010	2.039	1.292	1.543	1.734	1.825	1.693	1.893	1.546	1.464	1.490
0.090	0.081	0.107	0.127	0.083	0.073	0.099	0.076	0.057	0.037	0.090	0.061	0.051	0.083	0.056
1.216	1.447	1.345	2.312	1.651	1.881	1.064	1.438	2.284	1.623	1.096	1.553	1.425	1.114	1.093
0.061	0.066	0.082	0.095	0.057	0.062	0.078	0.075	0.055	0.031	0.066	0.046	0.045	0.066	0.042
1.111	1.094	1.614	2.878	1.991	2.104	1.018	1.369	1.666	1.617	1.715	1.397	1.474	1.397	1.236
0.045	0.041	0.063	0.088	0.046	0.047	0.052	0.047	0.033	0.022	0.059	0.032	0.030	0.050	0.031

Table 5. Values of mortality index R_i''' for females, using achievable target death rates as standard, for 12 cause-of-death groups and all causes: United States and 19 health service areas, 1969-71, and United States, 1976

[Standard error (s_i''') shown for certain cause-of-death groups]

Cause-of-death group, R_i''', and s_i'''	United States, 1969-71	United States, 1976	Health service areas, 1969-71			
			California			
			01	04	09	11
All causes:						
R_i'''	1.651	1.379	1.676	1.628	1.613	1.644
s_i'''	---	---	0.040	0.022	0.029	0.011
All malignant neoplasms:						
R_i'''	1.246	1.207	1.222	1.381	1.199	1.301
s_i'''	---	---	0.055	0.032	0.040	0.015
Diabetes mellitus:						
R_i'''	2.240	1.644	1.705	1.256	1.908	1.719
s_i'''	---	---	0.257	0.131	0.212	0.070
Diseases of the heart:						
R_i'''	1.691	1.377	1.437	1.301	1.421	1.589
s_i'''	---	---	0.062	0.034	0.046	0.018
Hypertension and stroke:						
R_i'''	1.858	1.362	1.360	1.708	1.335	1.646
s_i'''	---	---	0.114	0.076	0.086	0.035
Diseases of the arteries, arterioles, and capillaries:						
R_i'''	1.599	1.329	2.545	1.908	1.496	1.580
s_i'''	---	---	0.373	0.201	0.214	0.086
Acute bronchitis, influenza, and pneumonia:						
R_i'''	2.846	1.457	3.617	3.111	3.260	3.177
s_i'''	---	---	0.446	0.237	0.297	0.111
Bronchitis, emphysema, and asthma:						
R_i'''	1.869	1.360	4.239	1.730	3.841	2.160
s_i'''	---	---	0.648	0.210	0.503	0.119
Major digestive diseases, except cirrhosis of the liver:						
R_i'''	2.143	1.427	2.335	1.911	2.514	2.142
s_i'''	---	---	0.506	0.264	0.378	0.140
Cirrhosis of the liver:						
R_i'''	2.459	2.112	3.309	5.339	2.813	3.762
s_i'''	---	---	0.360	0.251	0.235	0.103
Congenital anomalies and diseases of early infancy:						
R_i'''	1.722	1.307	1.390	1.327	1.562	1.528
s_i'''	---	---	0.123	0.071	0.084	0.032
All other diseases:						
R_i'''	1.683	1.518	1.291	1.279	1.404	1.284
s_i'''	---	---	0.094	0.054	0.074	0.026
Accidental injuries and other trauma:						
R_i'''	1.729	1.524	2.856	2.426	2.239	2.238
s_i'''	---	---	0.154	0.078	0.093	0.035

NOTE: In everyday use for health planning, only three significant figures should be carried.

Table 5. Values of mortality index R_i''' for females, using achievable target death rates as standard, for 12 cause-of-death groups and all causes: United States and 19 health service areas, 1969-71, and United States, 1976—Con.

[Standard error (s_i''') shown for certain cause-of-death groups]

Health service areas, 1969-71														
Connecticut		Dela-ware	Florida		Loui-siana	Maryland			Michigan		New Jersey	Wash-ington	Wisconsin	
01	04	01	06	09	01	02	03	04	01	06	02	01	01	02
1.368	1.365	1.690	1.729	1.676	2.016	1.132	1.531	1.816	1.734	1.572	1.678	1.461	1.259	1.449
0.028	0.027	0.040	0.035	0.023	0.028	0.033	0.035	0.021	0.014	0.035	0.020	0.019	0.029	0.020
1.183	1.285	1.333	1.044	1.338	1.394	1.144	1.246	1.370	1.277	1.256	1.386	1.199	1.184	1.245
0.041	0.043	0.057	0.038	0.032	0.038	0.054	0.053	0.029	0.019	0.052	0.028	0.027	0.048	0.030
1.659	1.298	3.446	1.880	1.647	4.887	1.034	2.058	3.272	3.108	2.404	2.425	1.715	1.834	2.336
0.191	0.158	0.349	0.231	0.143	0.268	0.251	0.279	0.167	0.119	0.267	0.146	0.140	0.249	0.178
1.256	1.310	2.142	1.416	1.483	2.628	1.093	1.618	2.107	1.834	1.556	1.982	1.331	1.203	1.414
0.046	0.046	0.082	0.051	0.037	0.061	0.063	0.074	0.041	0.025	0.060	0.037	0.031	0.048	0.034
1.559	1.601	1.842	1.773	1.615	2.565	1.417	1.352	1.943	2.134	1.698	1.655	1.741	1.425	1.850
0.101	0.100	0.153	0.104	0.075	0.109	0.141	0.125	0.075	0.053	0.126	0.066	0.071	0.102	0.077
1.284	1.486	1.664	1.356	1.387	2.047	1.021	1.902	2.140	1.476	1.867	1.213	1.518	1.782	1.544
0.201	0.216	0.311	0.212	0.158	0.216	0.252	0.329	0.191	0.100	0.285	0.129	0.153	0.274	0.189
1.761	1.860	3.219	3.071	2.348	3.886	1.184	1.913	2.031	2.801	2.469	2.759	1.764	1.368	2.330
0.234	0.206	0.400	0.350	0.204	0.281	0.234	0.254	0.148	0.120	0.312	0.188	0.137	0.217	0.194
1.282	1.439	1.587	2.396	2.003	2.281	1.227	1.595	1.637	1.960	1.758	1.485	2.567	1.526	1.431
0.222	0.253	0.432	0.378	0.214	0.315	0.336	0.386	0.200	0.144	0.360	0.171	0.240	0.337	0.218
2.131	1.382	2.120	1.902	1.383	3.472	1.346	1.415	1.857	2.016	2.608	2.393	2.255	1.296	1.705
0.442	0.303	0.539	0.443	0.203	0.442	0.411	0.348	0.236	0.159	0.513	0.271	0.281	0.283	0.235
2.724	3.042	2.161	3.021	3.554	2.603	1.627	3.530	4.261	3.487	1.626	3.063	2.444	1.382	2.039
0.252	0.264	0.286	0.291	0.217	0.222	0.237	0.358	0.215	0.128	0.232	0.180	0.153	0.224	0.158
1.610	1.527	1.738	1.827	1.889	1.960	1.219	1.596	1.741	1.812	1.619	1.944	1.338	1.279	1.527
0.104	0.089	0.123	0.131	0.091	0.081	0.109	0.090	0.066	0.042	0.100	0.070	0.055	0.089	0.065
1.305	1.316	1.425	2.226	1.722	1.997	0.950	1.689	2.209	1.777	1.302	1.542	1.505	1.105	1.284
0.077	0.072	0.100	0.114	0.067	0.076	0.086	0.099	0.065	0.039	0.088	0.053	0.055	0.076	0.054
1.263	1.045	1.505	2.630	2.040	1.628	1.072	1.303	1.513	1.618	1.929	1.269	1.776	1.379	1.439
0.082	0.067	0.106	0.142	0.079	0.071	0.089	0.080	0.054	0.037	0.109	0.051	0.058	0.087	0.058

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