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Approaches to an Epidemiology of Health

MILTON TERRIS, MD

A new definition of health and its relation to disease and illness is presented, and various approaches to epidemiological studies of health are discussed.

Introduction

The most widely used current definition of epidemiology is that given by MacMahon and Pugh in their textbook: "Epidemiology is the study of the distribution and determinants of disease frequency in man."[1] This definition represents a considerable expansion of the concept of epidemiology beyond that enunciated by Frost in 1927: "the science of the mass-phenomena of infectious diseases."[2]

The expanded definition reflects a major change in epidemiological thinking and practice. As the infectious diseases declined in the industrialized countries, it became increasingly clear that the noninfectious diseases were the most important causes of illness, disability, and death. Epidemiologists began to shift their efforts in this direction, and the chronic diseases have become the dominant field of epidemiological research in these countries.

The new definition, however, no longer suffices, for the scope of epidemiological investigation has broadened beyond its boundaries. For one thing, the definition does not include trauma which, as a result of war and more limited forms of assault, as well as accidents and suicidal attempts, accounts for a considerable part of morbidity and mortality. Epidemiological studies of trauma—particularly that due to accidents and suicide—have been carried out in increasing numbers during the past several decades and need to be included in the conceptual framework of modern epidemiology.

Of greater importance, however, is the fact that the current definition fails to allow for an epidemiology of health. This failure reflects the attitude of my generation of epidemiologists that to speak of an epidemiology of health is equivalent to star-gazing. We considered that we had undertaken a large task in challenging a formidable host of chronic diseases with our puny tools, and were not inclined to waste time on an area that was not only vague and imprecise but had a Utopian aura. When the World Health Organization definition was quoted, we balked; we could not really accept the idea that "Health is a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity."[3]

To explore the validity and usefulness of the WHO definition of health, it is necessary first to be clear about our definitions of non-health. Epidemiologically, we may consider that the results of the interactions of host, agent, and environment may be diagrammed as shown in Figure 1. It should be noted that disease may occur without illness. Health and illness are mutually exclusive, but health and disease are not. A large proportion of the adult population carries the disease of atherosclerosis, yet only a small percentage gives evidence of illness. Tuberculosis, histoplasmosis, and sarcoidosis are examples of diseases in which healthy individuals are often discovered to have evidence of disease only because a routine chest X-ray is taken. Carcinoma of the cervix is found by cytological examination in numerous healthy women. Indeed, just as in the early part of this century it was learned that infection and illness are not synony nous, so in recent decades it has become abundantly clear that disease and illness are not the same.

Since health and disease may coexist, one cannot construct a continuum to show their relationship. On the other hand, health and illness are mutually exclusive by definition, and one may describe a health-illness continuum as indicated in Figure 2.

One of the virtues of Figure 2 is that it indicates that

Dr. Terris is Professor and Chairman, Department of Community and Preventive Medicine, New York Medical College, New York, New York 10029. This paper was presented at the Sixth Annual Meeting of the Society for Epidemiologic Research, Winnipeg, Manitoba, June 22, 1973.

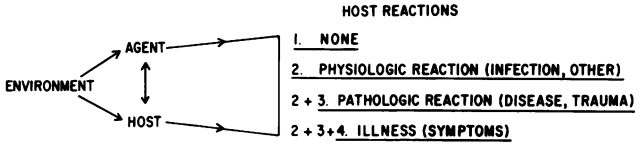

FIGURE 1 Host reactions.

there are degrees of health just as there are degrees of illness. Neither term represents an absolute.

How does one define health? Two major aspects of the definition may be considered, one subjective and the other objective. The subjective aspect relates to feeling well, the objective aspect to ability to function. The interrelationships of these aspects to health, illness, and disease are shown in Figure 3.

We may now consider the WHO definition: "Health is a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity." Clearly the word "complete" should be deleted, since health is not absolute; there are degrees of health. The term "disease" needs to be replaced by "illness" since, as indicated previously, health and disease are not mutually exclusive. This is emphasized in Figure 3 by the graphic presentation of the possibility of coexistence of disease with a maximum degree of health. And finally, health needs to be defined in functional as well as subjective terms. A revised WHO definition would thus read as follows: "Health is a state of physical, mental and social well-being and ability to function, and not merely the absence of illness or infirmity."

The Functional Aspect of Health

Although the subjective aspect of health is generally accepted, this may not be true of the functional aspect. In this connection it should be noted that the generally accepted definition of illness also has a subjective and a functional aspect; not only does the individual feel ill but there may be more or less interference with his ability to carry out his usual activities. Indeed, the severity of illness is determined largely by the degree of interference with function.

The functional aspect of health is dramatically illustrated by excerpts from the Report of a Royal Commission of inquiry which investigated the employment of children in factories in England in 1833. The three members of the Commission included two of the great sanitary reformers —heroic figures in the history of public health—Edwin Chadwick and Dr. Southwood Smith. In a biography of Dr. Smith,[4] his granddaughter wrote:

> "Their first work was to send district commissioners into the manufacturing regions to collect evidence, and the results of those inquiries were embodied in the general Report. My grandfather took a deep interest in the subject, for the evils disclosed by the inspection, if not so great as they had been under the apprenticeship system, were still sufficiently appalling: children, some of them not more than five years old, were obliged to work the same number of hours as the adult operatives—twelve, fourteen, or sixteen hours a day—sometimes the whole night....
>
> "It is sad to see in the Report such words as these, quoted from the children's lips: 'I am sick tired, especially in the winter nights.' 'So tired when I leave the mill that I can do nothing.' 'I feel so tired when I gang home that I throw myself down, no caring what I does.' 'So tired I am not able to set one foot by the other.' 'Many a time I have been so fatigued I could hardly take off my clothes at night, or put them on in the morning. My mother would be raging at me, because when I sat down I could not get up again'....
>
> "The evidence of the overseers and managers is scarcely less strong than that of the little sufferers themselves.... 'After the children from eight to twelve years old had worked eight or nine hours, they were nearly ready to faint: only kept to their work by being spoken to, or by a little chastisement to make them jump up. I was sometimes obliged to chastise them when they were almost fainting, and it hurt my feelings; then they would spring up and work pretty well for another hour; but the last two or three hours were my hardest work, for they then got so exhausted'.... 'I have seen them fall asleep, and they were performing their work with their hands, while they were asleep, after the 'billy' had stopped and their work was over.' "

It is difficult to read these accounts without experiencing a strong emotional reaction. It becomes almost heartless to describe the status of these children in an analytic fashion, to point out that both in terms of subjective feelings and objective function they were at the lowest level of health, just at the borderline of illness. Unquestionably, their probability of crossing that borderline, either temporarily or permanently, was very great. Although the data are not readily available, we may surmise that at the other extreme were the children of the factory owners. Well fed, well housed, and well cared for, they pursued their scholarly and recreational activities with abundant zest and vitality, that is, with marked "positive health."

The Several Approaches

Historically, the measurement of health status has proceeded from the most solidly established phenomenon, death, to include more severe illness, then mild illness, and finally health. The road traversed in this fashion has become progressively more difficult and uncertain. For this reason, the modest term "approaches" has been chosen to describe the various methods which have been used to study the epidemiology of health. These may be listed as follows: (1) measurement of performance, (2) studies of capacity for performance, (3) measurement of impediments to performance, and (4) studies of subjective feelings. Together, these approaches provide a sufficient framework for the construction of a scientifically valid epidemiology of health. There will be no attempt in this paper to give a comprehensive review of the different methods; the emphasis will be placed instead on specific examples of each approach.

Measurement of Performance

One of the most interesting illustrations of the measurement of performance is an experimental study done by Viteri[5] of the Institute of Nutrition of Central America and Panama. He compared 19 Guatemalan peons who had received a supplemental diet with 20 who had not. The supplemented peons were employed on a farm where, for the 3 years prior to the study, higher than average wages were

paid, cow's milk was easily available, and they received a daily supplement of Incaparina, which supplied 5.5 gm of high quality protein and 250 calories. The nonsupplemented group of peasants belonged to a particularly poor community located in an arid region of Guatemala. The intake of calories and protein was appreciably higher in the supplemented group, as was the percentage of protein with high biological value. The supplemented group had no mineral or vitamin deficiencies while the other group was deficient in vitamin A and riboflavin. At physically hard agricultural labor using rudimentary nonmechanized techniques the supplemented group maintained caloric balance but the nonsupplemented peasants did not, experiencing a substantial loss of weight. The most interesting finding, however, was that while the supplemented peons spent 33 per cent of their time at rest or asleep and 67 per cent of their time being active either at work or after work, the nonsupplemented peons spent 49 per cent of their time at rest or asleep and only 51 per cent of their time being active at work or after work.

More graphically, the author cites several subjective facts to confirm the suggestion that the nonsupplemented peasants "were extremely tired and almost exhausted during their work period, while the supplemented peasants were not. The second group often left us behind while climbing hills or moving on irregular terrain. The first group had the same intentions; they started with great stamina but soon we would catch up with them and even had to slow our pace to match theirs. Upon returning to the village this group of peasants tried not to look tired, but they appeared exhausted and disappeared into their houses for long periods of time. Later on they would come out and either sit quietly playing cards or stand and chat, while the supplemented peons would often work at home or walk around town or even play football."

This single small study cannot be said to be conclusive. Furthermore, the portrait of human fatigue which it evokes is not quite as devastating as that of the children who slaved in what William Blake called "those dark Satanic mills." But it is important on two counts: first, it indicates the enormous potential of nutrition for improving functional ability and well-being, and second, it suggests the need for reevaluating the significance of the epidemiology of health.

Viteri's work indicates that the epidemiology of health is not merely a luxury or fringe benefit for those sections of the population of industrialized countries who have already achieved considerable freedom from disease. On the contrary, it is precisely in those sections of the world which are poor and nonindustrialized and have the worst disease problems—and, as we shall indicate later, in those sections of the population of the industrial nations which are also poor and have the worst disease problems—that the question of the epidemiology of health is most important. If, as Viteri's work suggests, many millions of people—indeed, the majority of the world's population—are being robbed by malnutrition of almost one-fourth of their active life, of their vitality, well-being, and freedom from excess fatigue, then the issues involved in the epidemiology of health must be considered to stand among the major health problems not only for epidemiologists and workers in nutrition, but for the world public health movement as a whole.

HEALTH				ILLNESS			
++++	+++	++	+	+	++	+++	++++

FIGURE 2 The health-illness continuum.

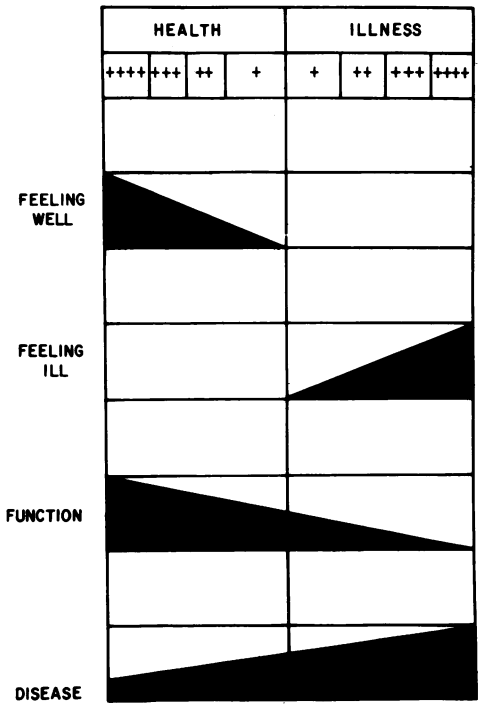

FIGURE 3 The health-illness continuum: subjective and objective aspects and relation to disease.

Let us return now to the children of Britain. In 1958 information was gathered in a Perinatal Mortality Survey on virtually every infant born in England, Scotland, and Wales during the week of March 3 to 9. This survey provided the cohort for a National Child Development Study which traced and studied these children when they were 7 years old. There were approximately 15,500 children in the study group.[6]

Figures 4 and 5 show the relation of the father's social class to the child's performance on arithmetic and reading tests. The social class designations are those used by the Registrar General: I, higher professional; II, other professional and technical; III (nonmanual), other nonmanual occupations; III (manual), skilled manual; IV, semiskilled manual; and V, unskilled manual.

It is clear from the figures that there is a considerable difference between manual and nonmanual workers with regard to their children's performance of the basic skills of reading and arithmetic. Among manual workers there is, furthermore, a progressive increase in the percentage of children with poor scores as the occupational level decreases. The manual workers, it should be noted, are not a

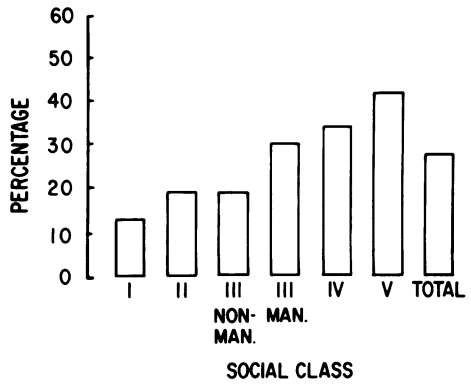

FIGURE 4 Percentage of children with poor problem arithmetic test score (0–3). From Davie et al.[6]

small group; they account for 67 per cent of the children as compared to 29 per cent for the nonmanual occupations (there was no male head of household for 3 per cent of the children).

Similar findings are reported for the United States by the National Health Survey, which examined a probability sample of approximately 7,000 children age 6 to 11 in 1963–1965.[7] Figure 6 shows the relation of family income to performance on reading and arithmetic tests. On both tests the successive differences in mean raw scores from one income level to the next higher level are statistically significant up to those in families earning $10,000 to $14,999. With few exceptions this pattern of relationship to income level was found throughout the age range.

On the face of it, these data do not appear to fall into the province of the epidemiologist; they are more likely the concern of psychologists and sociologists. As we shall see later, however, epidemiologists and other health workers are in fact making important contributions in this area.

Studies of Capacity for Performance

Studies of the potential or capacity for performance are of two major types. One type, which includes tests of physical fitness on the one hand and intelligence tests on the other, is only a step away from measurement of performance. The other type, which comprises the studies of growth and development in different populations, is much further removed from actual performance.

Physical fitness and physical education have no respected place in the American public health movement. Their practitioners have been labeled by at least one elder statesman of public health as "the big-muscle boys," and this contemptuous attitude has persisted to this day. It is, curiously enough, in sharp contrast to the situation in the Soviet Union where the goals of health legislation are defined as follows: "Health legislation of the Union of Soviet Socialist Republics and the union republics shall regulate relations of society in the field of public health with a view to promoting harmonious physical and spiritual development of the people, their health and general physical fitness. It shall facilitate prevention of diseases, reduction of morbidity, disability and death rates, and elimination of factors and conditions that may be responsible for harmful effects on the nation's health." Furthermore, "promotion of physical and health education, physical training and sports" is considered one of the fundamental principles of public health organization in the U.S.S.R.[8]

On the subject of physical fitness I speak with no authority. Having spent a large portion of my life seated at a desk, I have no personal acquaintance with the concept. On a more intellectual level, I have been far too bound by the philosophical rigidities of the American public health movement to become knowledgeable in the literature of this field, and am therefore in no position to judge the relation of physical exercise and physical fitness to performance of activities of daily living and to "physical, mental and social well-being," that is, to "positive health," vitality, and joy of life. These are issues which are eminently worth studying.

In addition to tests of physical fitness, there is a great deal of interest in tests of intellectual "fitness." Thus, in the United States, intelligence tests were administered by the National Health Survey in 1963–1965 to the same group of about 7,000 children that were given the reading and arithmetic tests referred to previously.[9] The results by family income are shown in Figure 7. The comments on statistical significance of differences for the reading and arithmetic tests, as well as the contributions of epidemiology to the explanation of those differences, apply here as well.

In contrast to physical fitness and intelligence tests, studies of growth and development provide a relatively indirect indication of potential for performance. This potential refers not only to physical performance but, as Birch[10] has pointed out, to performance in childbearing and perhaps also in the intellectual sphere.

In the United States,[11] there has been a marked increase in the average height of children since the beginning of the century; the height of 11-year-olds, for example, has increased by 11 cm for boys and 13 cm for girls (Table 1). European countries show a similar phenomenon. Thus, during the past 100 years in the Netherlands, the height of 5-year-olds has increased by 14 to 15 cm and of 10-year-olds by 17 to 18 cm.[12]

In the nonindustrialized countries, on the other hand,

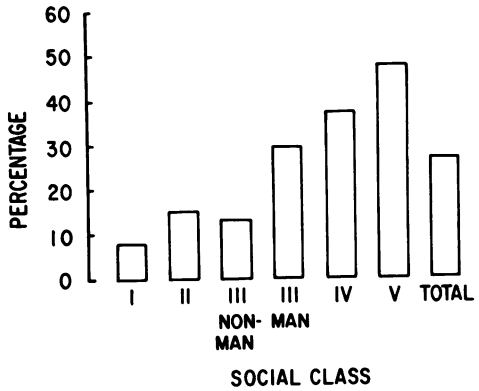

FIGURE 5 Percentage of children with poor Southgate reading test score (0–20). From Davie et al.[6]

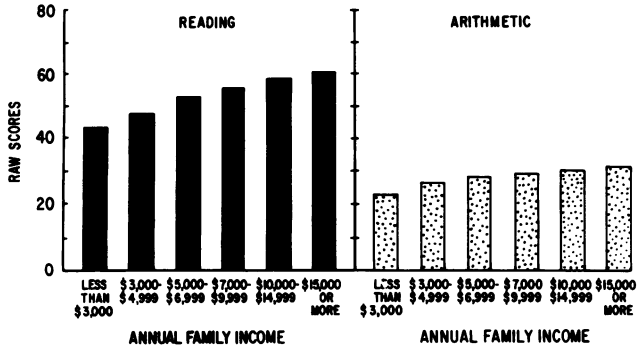

FIGURE 6 Average reading and arithmetic raw scores on the wide range achievement test for children, by annual family income, United States. From U.S. National Health Survey.[7]

growth and development are at a much lower level. Figure 8 demonstrates this for school age children in the United Arab Republic and in India.[11] For preschool children, the same gap is evident, as indicated by Figure 9 which compares the height and weight of Punjabi and Indian girls up to the age of 40 months with the Harvard standard; the data for boys are quite similar.[13] It is clear that the children of the Punjab fare poorly in comparison with India as a whole, although the latter is far below the Harvard standard. Similar findings for the preschool children of Indonesia, especially Central Java, are presented in Figures 10 and 11.[14]

There is a certain irony in this great difference in growth and development of children in industrialized and nonindustrialized countries. The industrial nations are producing larger, taller children for economies in which physical labor is less and less required. The agricultural nations, on the other hand, are producing smaller, shorter children to do the backbreaking manual labor in the fields.

There is considerable evidence that the difference between the two groups of nations in physical growth and development is fundamentally due to differences in nutrition.[10] But this is only part, and probably the smaller part, of the story. As John Dobbing of the University of Manchester has pointed out: "The possibility that undernutrition in early life may permanently reduce the intellectual capacity of men and women has become increasingly recognized in recent years. Attempts to investigate a causal relationship are in progress in many parts of the privileged and underprivileged world, and there can be few more important problems in the fields of human nutrition and preventive pediatrics. For our own species, unlike pigs, sheep, and cattle, carcass weight and even athletic prowess are considerably less important than achieving our full intellectual potential."[15]

Dobbing then goes on to state that: "Undernutrition has for too long been considered in adult terms as a series of deficiency diseases whose main consequences can be reversed on restoration of the deficient component. In pediatrics, we must now be much more concerned about undernutrition at certain vulnerable stages of development having long term sequelae which may be irreversible in spite of the most strenuous attempts at rehabilitation. Such sequelae are not like the easily detectable ocular scars of vitamin A deficiency. Neither are they focal lesions such as may be produced in the brain by acute hypoxia and kernicterus or Wernicke's encephalopathy. Instead they are diffuse deficits of growth attainment, some of which easily escape notice since they may never depress this attainment far below the lower limits of normality. Thus, we are postulating a new form of teratology of the brain. It is less dramatic than that which produces gross distortions of form, but one which, if it occurs, could have serious consequences for the intellectual well-being of whole sections of society, even in our own countries which we like to describe as well developed and civilized."

Laboratory, clinical, and epidemiological research on the relation of nutritional factors to intelligence and learning has burgeoned during the past decade. This is not the time or place to discuss the state of the evidence; there is available a comprehensive review by Birch[10] which appeared in the June, 1972, issue of the *American Journal of Public Health*. Two points need to be made, however. First, the epidemiological studies in this area are clearly not related to illness or disease, but rather to the performance and capacity for performance of healthy persons. Second, the problems here are of great importance both to individuals and to society. The majority of mankind is still being born into backward agricultural societies and subjected to the undernourishment which is pandemic in those societies. Furthermore, as Dobbing has taken pains to point out, there are large numbers of poor and undernourished children in

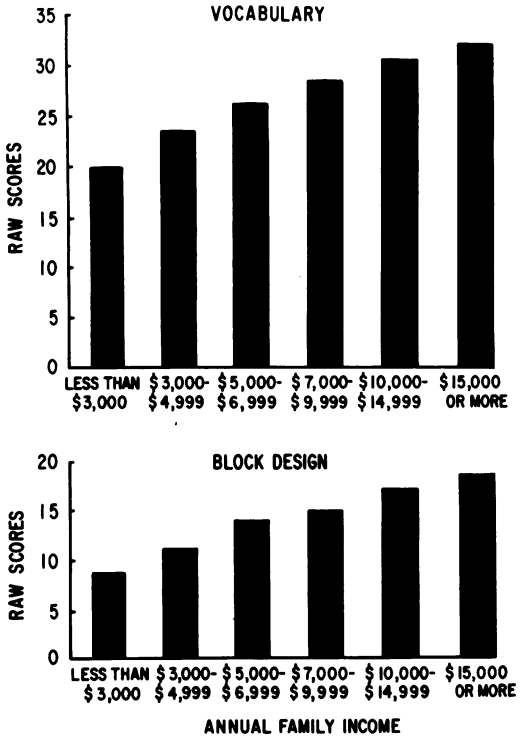

FIGURE 7 Average vocabulary and block design raw scores on the Wechsler Intelligence Scale for Children by annual family income. From U.S. National Health Survey.[9]

TABLE 1—Average* Heights of Children Age 6 through 11 Years at Specified Time Periods, by Sex and Single Year of Age: United States, 1902, 1923, 1946, and 1963–1965†‡

	Height							
	Boys				Girls			
Age	Hastings 1902	Baldwin-Wood 1923	Stuart-Meredith 1946	HES 1963–1965	Hastings 1902	Baldwin-Wood 1923	Stuart-Meredith 1946	HES 1963–1965
years	cm							
6	110.7	116.8	117.5	118.6	109.9	114.3	115.9	117.8
7	115.7	121.9	124.1	124.5	115.0	119.4	122.3	123.5
8	121.3	127.0	130.0	130.0	120.2	127.0	128.0	129.4
9	125.9	132.1	135.5	135.5	126.2	132.1	132.9	135.5
10	131.0	137.2	140.3	140.2	131.3	137.2	138.6	140.9
11	134.9	142.2	144.2	145.7	135.2	142.2	144.7	147.6

* Data are means for all years except 1946, for which they are medians. Means and medians for HES 1963–1965 data differ by less than 0.5 cm, or by less than 0.5 per cent.

† Note: Hastings' data are for children of Nebraska; Baldwin-Wood data are for children of the North Central and Northeastern States; Stuart-Meredith data are for children of Iowa; and HES data are for a probability sample of all children of the United States.

‡ From U.S. National Health Survey.[11]

the industrialized countries whose failure to perform well on reading, arithmetic, or intelligence tests may reflect not only social deprivation but the effects of undernutrition at critical periods of development.

Measurement of Impediments to Performance

There are large sections of the population who are healthy, that is, free from illness, but whose degree of health in terms of performance and capacity for performance is impaired by one defect or another. Some of the defects are the result of disease or trauma, others may be caused by physiological changes, and still others are of unknown etiology. In any case, they represent major hindrances to the achievement of a high level of health, and require a good deal more attention from epidemiologists and public health workers than they have received in the past.

The National Health Survey has provided valuable data on the prevalence of these impairments in the United States. For example, in 1960–1962, dental examination of a national sample of about 6,600 persons age 18 to 79 revealed that 18 per cent were edentulous.[16] The prevalence rate was 37 per cent at age 55 to 64, and 49 per cent at age 65 to 74. Fortunately, 78 per cent of the edentulous persons had satisfactory dentures; the remaining 22 per cent presumably suffered difficulties in eating and may well have had nutritional deficits as a result.

A health interview survey of about 268,000 persons conducted in 1963–1965 provided data on a variety of selected impairments.[17] The prevalence data, presented in Table 2, indicate that the problems posed by these impairments are fairly widespread in the population of the United States. Furthermore, as the survey also showed, they are responsible for a good deal of limitation of normal activity.

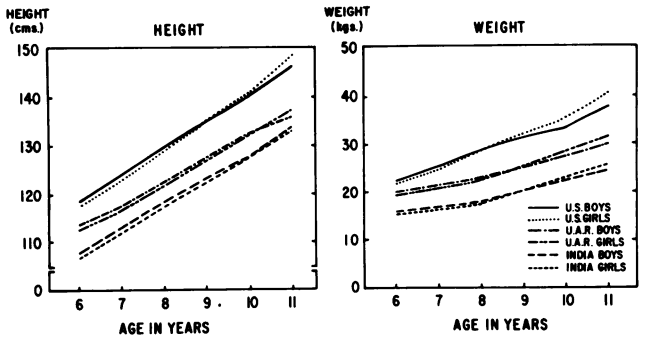

FIGURE 8 Mean height and weight for children age 6 through 11 years, by sex and single year of age: United States, United Arab Republic, and India. From U.S. National Health Survey.[11]

Follow-up of these descriptive epidemiological studies with in-depth analysis of etiological factors, and public health programs to prevent or correct the impairments or at least mitigate their effects, would undoubtedly result in improving the well-being and performance of large numbers of individuals.

Studies of Subjective Feelings

Finally, the degree of "physical, mental and social well-being" may be measured, at least in part, by studies of subjective feelings. One specific area in which this has been done is in the study of human reactions to temperature changes. In the original work by Houghton and his associates in Pittsburgh in 1924, thermal comfort was defined in terms of the scale: cold, cool, slightly cool, comfortable, slightly warm, warm, hot.[18] In 1937, C.-E. A. Winslow and his colleagues at the Pierce Laboratory in New Haven

studied thermal comfort with a verbal scale that avoided mention of thermal sensations, that is: very pleasant, pleasant, indifferent, unpleasant, very unpleasant.[19] They found that the subjective data obtained from their experimental subjects were sufficiently reliable to yield concordant and significant results which correlated closely with skin temperature and, in hot environments, even more closely with sweat secretion.

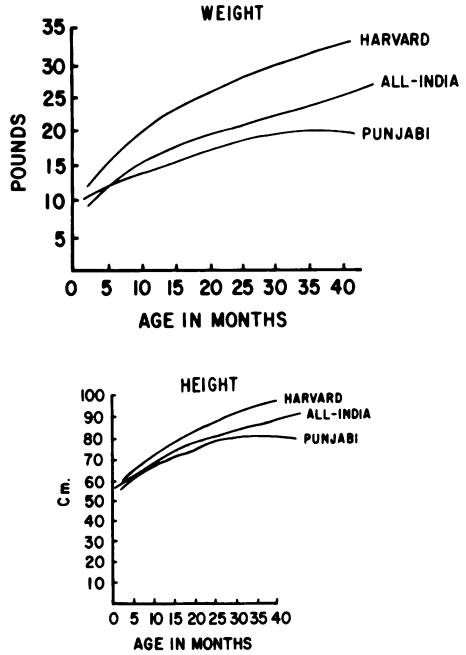

FIGURE 9 Comparison of Punjabi children, American standards, and all India females only. From Neumann et al.[13]

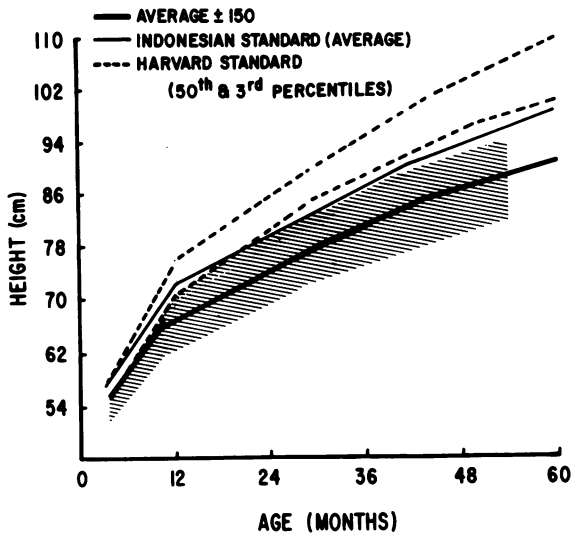

FIGURE 10 Height of preschool children in Central Java in comparison with Indonesian and American standards. Height and weight standards for American children are those of the Harvard survey (Nelson, W.E. Textbook of Pediatrics, Ed. 6, p. 49. W. B. Saunders Company, Philadelphia, 1964). From Tie et al.[14]

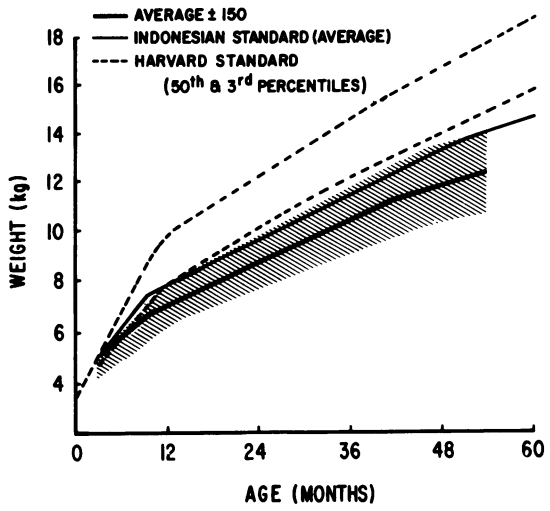

FIGURE 11 Weight of preschool children in Central Java in comparison with Indonesian and American standards. From Tie et al.[14]

TABLE 2—Average Prevalence of Selected Impairments: United States, July, 1963 to June, 1965*

Impairment	Avg No. (Thousands)	Rate/ 1,000 Population
All visual impairments	5,390	28.8
Severe visual impairments	1,227	6.6
Other visual impairments	4,163	22.2
Hearing impairments	8,549	45.7
Speech defects	1,298	6.9
Paralysis, complete or partial	1,516	8.1
Absence of extremities, all sites	1,968	10.5
Major extremities	257	1.4
Finger(s) or toe(s) only	1,712	9.1
Other impairments of limbs, back, trunk, all sites	17,742	94.8
Back or spine	6,486	34.7
Upper extremity and shoulder	2,925	15.6
Lower extremity and hip	6,623	35.4
Other and multiple, NEC	1,709	9.1

* From U.S. National Health Survey.[17]

Between 1951 and 1963, Goromosov[20] carried out large scale field studies in the U.S.S.R. with the object of establishing optimum health standards for the microclimates of homes in regions with hot climates. These studies were conducted in 13 towns in Kazakhstan, Turkmenistan, and Uzbekistan in Central Asia, all of which have hot, dry climates, and in Georgia, on the Trans-Caucasian shore of the Black Sea, where the climate is hot and moist. The outdoor temperatures ranged from 35° C to 38° C. The microclimates of 2,834 apartments were examined, and the state of health and physiological responses of 6,000 adults were studied as well as their subjective sensations according to a four-point scale: comfortable, warm, hot, hot and

TABLE 3—Physiological Responses in Human Subjects in a Cooled Room at Various Temperatures*,†

Physiological Reactions	Temperature of the Dwelling (°C)				
	Background‡	24–25	26–28	30–31	33–34
Mean skin temperature (°C)	33.0	33.3	33.6	34.7	35.6
Skin humidity (in arbitrary units)	1.7	1.8	5.2	18.2	20.8
Infrared radiation from skin (kcal/cm²/hr)	4.1	3.6	4.0	0.9	0.8
Vascular reaction of skin to cooling (time for return to initial temperature (sec))	200.0	200.0	260.0	290.0	290.0
Pulse rate (beats/min)	64	64–66	68	72	74
Respiration rate (breaths/min)	16	18	18	20	22
Subjective sensation	Comfortable	Comfortable	Warm	Hot	Hot and oppressive

* Relative humidity, 40 per cent; air movement, 0.10–0.15 m per sec; outdoor temperature, 35°C (mean data from 106 observations on 27 subjects).

† From Goromosov.[20]

‡ The initial level of physiological responses was established under optimum summer environmental conditions: in the early morning, in a dwelling with open windows, with the subject at rest.

oppressive. Experimental investigations were also carried out in air-conditioned rooms, and the results with respect to environmental conditions, physiological reactions, and subjective sensations are summarized in Table 3. Goromosov concluded from his field and experimental studies that for air-conditioned homes in hot climates where the outdoor temperature is 35° C, the recommended indoor temperature should be 23–25° C, the relative humidity 50–55 per cent, and the air velocity 0.15–0.2 m per sec.

The studies of subjective sensations in relation to thermal changes are relatively simple and are made with confidence because the results can be checked with the simultaneously obtained physiological and environmental data. These favorable conditions, however, are not usually available. To study degrees of wellness, and different aspects of wellness such as comfort, well-being, and vitality, will not be easy or simple. Nevertheless, the development of an epidemiology of health makes it essential to create and improve the instruments and methods needed for studies of subjective feelings, since health is appropriately defined not only as ability to function but as "a state of physical, mental and social well-being."

Conclusion

It has been the purpose of this paper to attempt to clarify the concepts and interrelations of health, illness, and disease; to demonstrate that the epidemiology of health is not a luxury or a minor concern but rather an area of crucial significance to the majority of the world's population; and to indicate the variety of approaches that have been used in its scientific pursuit. Much more can and will be done in the scientific development of an epidemiology of health. A precondition, however, is the casting off of the narrow viewpoints and constricting traditions which hinder interest and activity in this field.

The public health worker who, perhaps more than any other, campaigned for the abandonment of limited conceptions and rigid traditions was Joseph W. Mountin of the U.S. Public Health Service, one of the great leaders of public health in this century. In 1947, at the Institute on Social Medicine held at the New York Academy of Medicine, he called on public health to expand its horizons beyond the infectious diseases with his classic comment that "It is time we got off the Broad Street pump." Ten years earlier, at the Fifteenth Annual Conference of the Milbank Memorial Fund, he had insisted that "people who call themselves health workers should go beyond disease and into the broader fields of human comfort and vitality."[21]

Epidemiologists are proud to call themselves health workers, although there are some who resist the designation. It is not too late—36 years is a short time in public health—to take Mountin's advice seriously and to go beyond disease into the broader fields of human comfort and vitality, into the complex, difficult, and eventually rewarding science of the epidemiology of health.

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