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AN EVALUATION OF THE FACTORS RESPONSIBLE FOR PUBLIC HEALTH PROGRESS IN THE UNITED STATES[1]

By Dr. MURRAY P. HORWOOD

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ONE of the striking phenomena of the twentieth century and to some extent also of the last quarter of the nineteenth century has been the curtailment of premature mortality, the prevention of disease and the prolongation of the average life span of man. Since 1880, the general death rate has been diminished more than 50 per cent. and the average expectancy of life at birth has been increased from 40 years to approximately 61 years. Typhoid fever and diarrhea and enteritis have diminished almost to the vanishing point in many communities; cholera and typhus fever are rarely causes of death in this country to-day; the incidence and deaths from diphtheria have been greatly reduced; smallpox is under control in all communities where vaccination is practised; bubonic plague, though endemic in certain restricted areas, is not responsible for many cases of disease or many deaths; the infant death rate has been diminished more than 75 per cent.; the death rate from tuberculosis, at one time the most important single cause of death, has been reduced 75 to 80 per cent.; hookworm is controlled in the South; yellow fever is now non-existent in this country; and malaria is under better control. This remarkable progress in public health occurred during a period of rapid and increasing urbanization and congestion in this country, when conditions should have favored high death rates. Obviously, some factor or factors must

[1] Contribution No. 146 from the Department of Biology and Public Health, Massachusetts Institute of Technology, Cambridge, Mass.

have been at work to effect this tremendous saving of human life, and a correct evaluation of these factors should therefore be of great interest and value. Shryock[2] describes the conditions that prevailed prior to the advent of modern public health measures as follows:

The tragic history of the major endemic diseases, typhus, typhoid and tuberculosis, is familiar enough. So far as can be judged from the imperfect bills of mortality, urban death rates rose ominously during the first half of the nineteenth century. New York City, which was most inundated by poor immigrants and which grew most rapidly, affords a striking example. In 1810, the crude death rate had been reported as about 21 per 1,000; by 1857, it had risen to around 37 per 1,000—an increase of almost 80 per cent. within 50 years. Rates were lower in Philadelphia, but higher in New Orleans. What an increasing mortality implied in morbidity rates, to say nothing of "subclinical illness," is obvious enough.

And in 1937, the estimated general death rate for the United States, based on 85 per cent. of the total population, was 10.9 per 1,000 population.[3]

The remarkable saving in human life can not be appreciated fully from a mere citation of reductions in death rates and the increase in the average expectancy of life at birth. It is necessary to know the difference between the actual number of deaths occurring to-day and the number of deaths that would have occurred if the old death rates still prevailed. This information is presented in Table 1 for the years 1900 and 1935, both for all causes of death as well as certain principal causes.[4]

It is evident from Table 1 that approximately 768,000 lives are saved annually among the white population of the United States as a result of the curtailment in the death rate since only 1900, an extraordinary achievement based on magnitude alone but one that can hardly be evaluated in terms of the prevention of human misery and suffering and in terms of the maintenance of the unity of families. Among the outstanding achievements noted in the preceding table are the reduction in the deaths from tuberculosis, influenza and pneumonia, diarrhea and enteritis, diphtheria and typhoid and paratyphoid fevers. The saving of life from these diseases alone is equivalent to 61 per cent. of all the lives saved by the reduction in mortality since 1900.

TABLE 1

ACTUAL DEATHS IN THE WHITE POPULATION OF THE UNITED STATES DURING 1935 FROM ALL CAUSES OF DEATH AND FROM SEVERAL PROMINENT CAUSES OF DEATH, COMPARED WITH THE CORRESPONDING NUMBERS EXPECTED IN THAT YEAR ON THE BASIS OF THE MORTALITY RATES BY SEX AND AGE PREVAILING IN 1900*

Cause of death	Deaths in 1935		Lives saved in 1935 by improvement in mortality since 1900	Lives lost in 1935 by retrogression in mortality since 1900
	Actual	Expected on basis of mortality in 1900		
All causes	1,207,359	1,975,761	768,402	
Tuberculosis, all forms	51,269	224,384	173,115	
Influenza and pneumonia†	110,191	232,187	121,996	
Diarrhea and enteritis‡	17,018	125,448	108,430	
Principal communicable diseases of childhood	13,182	72,127	58,945	
Measles	3,435	12,590	9,155	
Scarlet fever	2,646	9,336	6,690	
Whooping cough	3,673	10,715	7,042	
Diphtheria	3,428	39,486	36,058	
Typhoid and paratyphoid fever	2,386	35,652	33,266	
Nephritis	89,240	115,239	25,999	
Cerebral hemorrhage and softening	85,732	102,535	16,803	
Puerperal state	10,018	14,504	4,486	
Organic heart disease	212,167	153,584		58,583
Cancer	129,124	86,103		43,021
Diabetes	26,606	14,301		12,305
External causes (excluding suicides)	94,851	84,688		10,163
All other causes	365,575	715,009	349,434	

* As observed in the original death registration states and the District of Columbia, 1900.
† Excluding capillary bronchitis.
‡ Includes duodenal ulcer.

Contrariwise, there has been no reduction in the mortality from such diseases as organic heart disease, cancer and diabetes or from external causes. Their significance has rather increased as the population has grown older and as the more readily preventable deaths have been brought under control. The ten principal causes of death in the United States to-day,[5] presented in the order of their importance, are heart disease, cancer, pneumonia, nephritis, accidental violence, cerebral hemorrhage, tuberculosis, congenital malformations and diseases of early infancy, diabetes and in-

[2] Richard H. Shryock, *Am. Jour. Public Health*, 27: 10, 965–971, October, 1937.

[3] *Public Health Reports*, 53: 18, 701–719, May 6, 1938.

[4] Metropolitan Life Insurance Company, *Statistical Bulletin*, 18: 11, 3, November, 1937.

[5] Metropolitan Life Insurance Company, *Statistical Bulletin*, 19: 8, 7, August, 1938.

fluenza. The relative significance of these causes of death varies with the section of the country under consideration, but, for the country as a whole, they represent the ten leading causes of death. Heart disease is responsible for nearly 25 per cent. of all the deaths in the United States, and its annual toll is more than twice the number of deaths resulting from cancer. Many of the "Big Ten" represent the degenerative diseases. How much can be done to prevent mortality resulting from senility and from the wear and tear of daily living by recognized public health and medical procedures is decidedly problematical.

Reference has been made already to the extension of the average expectancy of life at birth since 1880. This progress was not limited to the last two decades of the nineteenth century, but has continued into the twentieth century as well. The actual progress along this line since the beginning of the present century is indicated in Table 2.[5]

TABLE 2

EXPECTATION OF LIFE AT BIRTH AMONG TOTAL PERSONS (WHITE AND COLORED) AND AMONG WHITE PERSONS BY SEX FOR THE UNITED STATES FROM 1901 TO 1936

Year	Expectation of life at birth in years		
	Total persons	White males	White females
1936*	60.81	60.18	64.36
1935*	61.37	60.72	64.72
1934*	60.79	60.24	64.18
1933*	61.26	60.86	64.40
1932†	61.07	60.69	64.38
1931†	60.26	59.88	63.56
1929–1931	59.57§	59.31‖	62.83‖
1919–1920¶	....	55.33	57.52
1910‡	51.49	50.23	53.62
1901‡	49.24	48.23	51.08

* Total United States.
† United States, excluding Texas.
‡ Original death registration states.
§ This figure relates to 1930 only for the United States, excluding Texas.
¶ Aggregate of 27 states; not computed for total persons.
‖ United States, excluding Texas and South Dakota.

During the first three decades of the twentieth century, the average expectancy of life at birth was increased by almost exactly eleven years—in spite of a devastating influenza-pneumonia epidemic and our participation in the World War with its attendant loss of life. Since 1930 there has not been any significant variation in average longevity. Perhaps the limit is being reached in our ability to prevent death with our present knowledge. It may be necessary for us to await the further contributions of the biologist, chemist and physicist in order to achieve additional success in deferring death. It is of interest to note, however, that at age 34 the average citizen has just as many years ahead of him as behind him; that at age 46, the average citizen may still look forward to a quarter century of life; and that even for those fortunate individuals who have attained the proverbial threescore years and ten, there still remain, on the average, 9.25 years of life.

According to Britten,[6] the causes of death listed in Table 3 were responsible for 81 per cent. of the total mortality in the United States in 1933.

TABLE 3

DEATH RATES PER 100,000 OF THE POPULATION IN THE U. S. IN 1933 BY SPECIFIC CAUSE, ARRANGED IN ORDER OF NUMERICAL IMPORTANCE

Cause of death	Death rate per 100,000 population
Diseases of the heart	228.0
Cancer and other malignant tumors..	102.2
Influenza and pneumonia	95.6
Nephritis and other kidney diseases..	85.7
Cerebral hemorrhage	84.0
Tuberculosis, all forms	59.5
Diseases of early infancy and congenital malformations	50.6
Automobile accidents	24.7
Diabetes mellitus	21.3
Diarrhea and enteritis	17.2
Arteriosclerosis	16.8
Suicide	15.9
Appendicitis	14.1
Puerperal state	10.3
Hernia and intestinal obstruction	10.0
Homicide	9.6
Gastritis	9.1
Syphilis	8.8
Cirrhosis of liver	8.7
Gall bladder diseases	6.9
Prostate diseases	6.0
Tumors, benign	4.6
Diphtheria	3.9
Tonsilitis	3.8
Malaria	3.7

The data presented in the preceding table indicate the principal causes of death in the United States and their relative importance. They are not always synonymous with the conditions or diseases that incapacitate an individual. They demonstrate once more that many of the conditions that result in death are due to the aging of the body or to non-preventable organic defects.

"Modern longevity is the product of modern enlightenment. Man himself, as a physical and physiological unit, has probably changed but little since remote antiquity. But man's power over his environment has changed immensely."[7] It would seem that man's increasingly effective mastery over a defective environment and his genius in developing biological and chemical agents for the prevention and treatment of certain diseases have been largely responsible for the progress that has been made. The demonstration of Pasteur that germs were responsible for fermentations and by Koch that germs were responsible for animal and human diseases made it possible to establish a new theory of the sources and modes of infection which in turn led to the virtual control of such diseases as typhoid fever, cholera, dysentery, paratyphoid fever and other ailments in this and other countries where public health progress has been marked. The demonstration by Theobald Smith that insects can be vectors

[6] Rollo H. Britten, *Public Health Reports*, 51: 29, 947–969, July 17, 1936.

[7] Louis I. Dublin and Alfred J. Lotka, "Length of Life," p. 154. The Ronald Press Co., New York, 1936.

of disease led eventually to the conclusive evidence by Ronald Ross that the anopheles mosquito was involved in the life cycle of the malarial parasite and its transmission to man. This work undoubtedly influenced the American Yellow Fever Commission in Cuba at the beginning of the twentieth century in their study of yellow fever which led ultimately to the demonstration that yellow fever is also a mosquito-borne disease. Thus two of the great scourges of man were attacked with newer knowledge and were brought under more effective control. The same held true for other insect-borne diseases, such as typhus fever and bubonic plague, as well as those diseases that are transmitted by flies. The effective control of the environment has brought under control in this country the intestinal and insect-borne diseases.

The establishment of the germ theory of disease was also responsible for the application of disinfectants and germicides to surgical wounds and to pyogenic infections of every variety, and led first to antiseptic surgery and later to aseptic surgery. It also stimulated research into the development of newer and better germicides. In this work many bacteriologists and chemists have cooperated. To these scientific workers the world is indebted for the introduction of new and better weapons in the conquest of disease, and for making it possible for surgeons to explore the human body with relative impunity and to perform radical operations to save human life which would have been impossible but a scant 50 or 60 years ago. The development of sulphanilamide in recent years is a good illustration of a life-saving contribution by a scientific worker. Likewise the discovery of x-rays and radium rays by physicists and chemists has had far-reaching effects both in the diagnosis and treatment of human disease. Many lives have been saved by the judicious use of germicidal agents; pyogenic infections have been prevented or controlled and surgery has been rendered safe beyond all human expectations. This success in preventing disease, controlling death and prolonging life is due to a more effective control of the environment.

Another aspect of environmental control which has had a profound effect on human health and vitality has been a combination of cleanliness, refrigeration and heat treatment in the production and safeguarding of many foods. In no instance is this success so obvious as in the protection of city milk supplies in the United States. An important but perishable food, often laden with dung and disease, has been sanitated, refrigerated and rendered safe through pasteurization. As a result, milk-borne diseases, including typhoid fever, diphtheria, scarlet fever, septic sore throat, undulant fever and tuberculosis of bovine origin, have been brought under control, and rarely occur in our large cities, where all or nearly all the milk supply is pasteurized. In all probability, there is not another country in the world where the milk supply is as clean and as safe as it is in the United States. The significance of this condition in infant and child health and in the nutrition and health of the entire population can hardly be over-estimated.

What has been accomplished in sanitating and safeguarding our public milk supplies has been matched with equal effectiveness in the purification and protection of our public water supplies and in the protection and safety of other aspects of our food supply. Most of this has been achieved through engineering effort—man's effective control over his environment to protect his health and to promote his comfort and convenience. When one realizes that billions of gallons of water are used and consumed in the United States every day; that this vast amount of water is purified or safeguarded and then rendered safe usually by chlorination; that one may travel the length and breadth of a great and populous continent and feel reasonably certain that the water can be consumed in the raw state with impunity; that this magical accomplishment so essential to health and life must be repeated without interruption day after day; only then can one begin to appreciate the debt which society owes to the activity of the public health engineer. Any serious interruption in the continued flow of water to our large cities or any serious infection of the public water supply which was not eliminated or controlled would make a mockery of our urban civilization and would create an epidemic situation that would make the pandemic of influenza-pneumonia of 1918 seem like a mild outbreak of disease.

Through other engineering developments in the fields of refrigeration, cold storage and rapid means of transportation, coupled with sanitary and veterinary inspections, our solid food supply has been safeguarded and delivered to every community in a fresh condition. Food is the source of all human energy and for that reason is basic in the maintenance of life and in building up the vital resistance of the body against disease. A clean, fresh and wholesome food supply is a basic public health requirement. Happily through the use of cookery—another step in man's control over his environment—our clean, fresh and wholesome food supplies have also been rendered absolutely safe.

The construction of a new road or a new link to a main railroad may mean more in promoting the health of a community than any other thing the community may do. Rapid means of transportation are essential for bringing food into the community in sufficient variety and freshness. Rapid means of transportation are also necessary to bring tools and other equipment

into a community in order to aid the people in their efforts to master their environment; and control over one's environment is essential for promoting and maintaining good heatlh.

The construction of sewers and the building of sewage treatment plants have done much to remove a nuisance and menace to health in the vicinity of the home. Because sewage treatment hasn't kept pace with sewer construction, the improper disposal of sewage has created newer public health problems which demand solution. Public water supplies, shellfish growing areas, bathing places and recreational and camp sites must be protected against sewage pollution. The country is slowly but surely making progress in the elimination of some of the worst cases of pollution. Chicago altered the natural course of a river in order to avoid polluting its drinking water with its own sewage. Since then it has built sewage treatment works to cope with the problem of pollution more effectively. New York, New Haven, Providence, Baltimore, Milwaukee, Indianapolis and many other cities have built sewage treatment plants and are operating them continuously. It is expected that badly polluted streams will be improved; that fish life will return; that land values will improve and that the other undesirable features of uncontrolled sewage pollution will be prevented or greatly ameliorated.

The introduction of the water closet into the home and the provision of adequate plumbing facilities with hot and cold running water has doubtless had a very significant effect on the health, comfort and convenience of a great portion of the population. However, it is impossible to evaluate its significance in terms of preventable diseases and deaths. It has eliminated the privy from the vicinity of the home with its attendant nuisances and health hazards. It has helped to suppress flies. It has favored intestinal hygiene throughout the year. It has made for human comfort, convenience and decency. It has promoted hand hygiene, mouth hygiene and body cleanliness. It has stimulated sanitation in the home and the cleanliness of foods and eating utensils. It represents another environmental factor which has definite public health significance.

In rural areas and in unsewered sections of cities, the construction of fly-tight privies has controlled soil pollution and the breeding of flies and has served as a factor in the control of intestinal diseases, including hookworm. This public health engineering activity also represents an advance in man's effective control of his environment.

Other items in man's control of his environment which have promoted the public health in the broadest sense include the control of insects and rodents, the sanitation of food stores and restaurants, the sanitation of public buildings and public conveyances, the removal and proper disposal of all forms of municipal refuse, the sanitation of shellfish and shellfish growing areas, of swimming pools and bathing places, of summer camps and tourist camps, boarding houses, hotels and other similar places. In addition, campaigns against noise, smoke, odors and other community nuisances have been waged and effective results obtained in many instances. The problem of heating and ventilation and of air conditioning in general has received a great deal of consideration. This is true both for domestic residences as well as for business and industrial establishments. As a result, air-conditioning in the home is becoming more adequate and satisfactory; while in industry excessive dusts, heat and humidity and obnoxious or injurious fumes, vapors and gases are being removed. The relationship of sunlight to physical and mental health has also received some consideration, as well as the removal of the agents of disease from the atmosphere of large assembly halls. These factors affect the vital resistance of the individual and hence the public health.

Reference has been made to the improvement of man's industrial environment and its effect on his health and comfort. Included in the same category are the prevention of industrial accidents of all types, improvement in illumination, avoidance of excess fatigue and over-exposure, the provision of rest periods, the curtailment of the work-day, the provision of vacations with pay and the whole gamut of changes in the industrial structure which consider the health and well-being of the worker to an ever-increasing degree. Recently, there has been a rapid acceleration of interest on the part of public health workers in the field of industrial hygiene and sanitation. In many instances state divisions of industrial hygiene have been formed under the auspices of the health department. Most of the larger industries have had such divisions of their own for many years, and these invariably have produced very satisfactory results. In nearly every state, special statutes exist which regulate the conditions of employment and which aim to protect and promote the health and welfare of the worker.

Industrial hygiene and sanitation have two aspects, medical and engineering. The engineering aspect includes the chemical where such problems exist. It is obvious that from the standpoint of environmental control in industry—that control which affects the health and welfare of *all* the workers in a factory or a part of it—the engineering aspect is of predominant importance. It is another sphere of public health activity in which the public health engineer has played and is continuing to play in a greater measure a rôle of real importance.

Still another aspect of environmental control which is receiving increasing attention is the matter of providing healthful housing for our population. The problem is an old one, and much improvement has

been accomplished over the past five or six decades. The issue has been elevated to a position of national importance and concern through the appropriation of vast sums of money by the Federal Government for slum clearance, and through the activity of the American Public Health Association Committee on the Hygiene of Housing as well as other groups. Healthful housing conditions favor good health in a variety of ways, and since the home is the environment of the individual for 8 to 24 hours each day, its public health significance is of appreciable importance. It involves such questions as water supply, sewerage, refuse disposal, drainage, insect and rodent control, lot overcrowding, congestion in the home, safety from fire and accidents, air conditioning, access to sunlight, freedom from noise, odor and smoke nuisances, play space for children and various other items of significance to the public health in the broadest sense.[8]

Another environmental factor which has had an unmeasurable but significant effect on the prevention of disease and premature mortality and the promotion of good health has been the improvement in the standard of living. Working hours have been reduced, rest periods in industry have been introduced, the minimum age of employment has been fixed by law in many instances and real wages are more satisfactory than in any other country in the world. Added to this improvement in social conditions has been the great progress in industrial hygiene and sanitation outlined above. More significant still is the revolutionary change in our knowledge of what constitutes an adequate and satisfactory diet and the application of that knowledge to the daily lives of our people. While much progress can still be made in the scientific and adequate feeding of our population, the fact remains that the wide-spread use of vitamins and minerals in the diet, coupled with proteins, carbohydrates and fats, has helped to build up and maintain the resistance of the population against disease. Adequate and satisfactory nutrition is the foundation on which the public health must rest.

This conclusion is supported by the happy but anomalous experience of the depression period, 1930–1936. In spite of wide-spread unemployment and curtailed health department budgets; in spite of diminished public health clinical and nursing activities, the health of the people either did not suffer at all or did not suffer sufficiently to be reflected in the death rates. As a matter of fact, the general death rates for the period under consideration showed a downward trend and the average expectancy of life at birth actually increased somewhat. This is borne out by the statistics cited in Table 4.[9] We have the apparent anomaly, therefore, that the public health in the United States seemed to improve during great economic distress and in spite of curtailed health department budgets.

TABLE 4

GENERAL DEATH RATE, UNITED STATES REGISTRATION AREA, 1921–1936

Year	Death rate per 1,000 population
1921	11.6
1922	11.7
1923	12.2
1924	11.7
1925	11.8
1926	12.3
1927	11.4
1928	12.1
1929	11.9
1930	11.3
1931	11.1
1932	10.9
1933	10.7
1934	11.0
1935	10.9
1936	11.5
1937	10.9*

* Based on data for 40 states representing 85 per cent. of the total United States population. Cited in *Public Health Reports*, 53: 18, 708, May 6, 1938.

What are the reasons for this anomaly? Perhaps they will never be known. Certainly no public health worker would advocate the curtailment of health department appropriations as a means of cutting the death rate and extending the life span. The answer, I believe, is found in the fact that the public health is intimately dependent on the control of the environment and that public health clinical activities are not important to the same degree. During the depression, our public water supplies were still purified, our sewers continued to function, public milk supplies were still safeguarded by pasteurization, food supplies were still safeguarded as to freshness, wholesomeness and absence of infection, and above all nobody was allowed to die of starvation or of cold. As a matter of fact, relief agencies insisted on at least a minimum but entirely complete and well-balanced diet, and the same agencies provided fuel for protection against the cold. As a result, the vital resistance of the people was maintained and excess disease and deaths did not occur. There were also certain definite public health advantages that can be credited to the depression. Exposure to industrial hazards and accidents was greatly diminished, smoke pollution of the atmosphere was greatly abated and people had more time for rest and relaxation. As a result, even the death rate from tuberculosis[10] continued downward rather than upward, as might have been expected, for in 1933 the rate in 41 states was 55.5 per 100,000 population; in 1934, it was 52.9; in 1935, 51.6; in 1936, 51.7 and in 1937, 49.6.

Another environmental factor which has had a real but unmeasurable effect on health and vitality has been

[8] M. P. Horwood, "Housing and Health." *The Commonhealth* (Mass. Dept. of Public Health), 25: 95–102, June, 1938.

[9] *Public Health Reports*, 53: 5, 168–171, February 4, 1938.

[10] *Public Health Reports*. 53: 701–719, May 6, 1938.

the conscious provision of playgrounds, parks and recreational facilities for the people. Coupled with this has been the growing practice of providing vacations with pay for the industrially employed. In France and Germany this practice has been fostered by the state. In the United States, it is largely the responsibility of private business and industry. Whatever the auspices, the body has an opportunity for periodic rest and relaxation without financial anxiety, and this, coupled with life in the open to a greater or lesser extent, has a beneficient effect on the public health.

Finally, the significance of the environment in the public health picture can be appreciated also by imagining what would happen in a short time to our much-vaunted civilized security if we ceased to protect our water supplies or interrupted their distribution; if the sewerage systems of our cities ceased to function; if garbage and other refuse materials ceased to be removed from the home by organized methods; if city milk supplies ceased to be pasteurized or heated in the home; if all industrial safeguards were suddenly removed and ceased to function. It is very simple to visualize what would happen, for New York City had two experiences recently that illustrate very graphically that human health and well-being are fundamentally dependent on the continued and effective control of the environment.

The first condition resulted when the flow of electric current below 59th street was interrupted for a brief period—30 minutes or more—shortly after 5 P.M. during the winter season. The subways and elevated lines ceased functioning at the hour of maximum demand; elevators in buildings stopped operating; electric heaters and electric refrigerators ceased to function; likewise electric pumps for water, milk and all possible uses; houses, stores, offices and city streets were thrown into utter darkness and people into utter panic because of fear of theft and the unleashing of man's worst instincts. Here the continuance of public health and public safety was dependent on the prompt resumption of the flow of electricity—a purely environmental factor.

The second illustration refers to the strike among the elevator operators in Manhattan. It is only necessary to mention such a condition to one familiar with the situation in New York to appreciate its public health significance. Elderly people with weak hearts could not do much climbing without running serious risk of irreparable damage. All the food had to be carried upstairs and the seriousness of this problem can be easily recognized. All the garbage had to be carried or thrown downstairs and one can readily imagine that even the fashionable environment of Park Avenue suffered somewhat. We must agree with Wolman[11] that "civilization rests upon a thin crust of environmental protection."

Charles Gilman Hyde[12] has presented a very thorough picture of the indispensability of the public health engineer to-day. Those individuals who say glibly that the public health movement has evolved through three stages—the control of the environment, the period of the bacteriologist and the period of the physiologist—and who say further that the era of environmental sanitation is behind us, know not whereof they speak. The era of environmental sanitation must be with us constantly if we are to maintain the great gains in human health that have been accomplished; and the control of the environment in the broadest possible sense must be extended to new limits if we are to meet the other aspects of healthful living—the promotion of the comforts and convenience of organized society.

This review has shown, I believe, that there exists an intimate relationship between the effective control of the environment and the great progress that has been made during the past 50 or 60 years in preventing disease and premature mortality, in extending the average expectancy of life at birth and in promoting joyous, healthful living. The control of the environment has not been the only factor involved, as will be demonstrated presently, but that it has been very significant can not be denied. Further support of the significance of effective environmental control in promoting the public health even to-day was presented at the convention of the American Public Health Association in New York in 1937 by Dr. Livingston Farrand, president-emeritus of Cornell University, who said at one of the great general meetings that "the two outstanding public health problems in the United States to-day are housing and nutrition." The first includes the elimination of slums and low standard housing areas and their replacement with suitable housing facilities; while the second deals with the important problem of providing an adequate and properly balanced diet for every man, woman and child. Both factors affect the public health through their influence on the vital resistance of the individual; while the housing factor also plays a rôle in his comfort and happiness.

In addition to the work of the public health engineer various other factors have played important parts in the public health progress that has been made since 1880. During this period, bacteriology has blossomed into a highly developed science. Not only have many of the etiological agents of disease been determined, but numerous laboratory aids in the diagnosis of disease have been developed. These have assisted greatly in making early and definite diagnoses—a prerequisite

[11] Abel Wolman, *Am. Jour. Public Health*, 27: 1, 43–49, January, 1937.

[12] Charles Gilman Hyde, *Am. Jour. Public Health*, 26: 7, 697–710, July, 1936.

to effective treatment and even to the prevention of secondary cases in certain diseases.

Another factor has been the development of biological products for the diagnosis, prevention and treatment of certain diseases. It is unnecessary to list all of them here, since the student of public health is quite familiar with them; but typhoid vaccine, smallpox vaccine, toxoid, antitoxin, anti-pneumococcus serum and various other biological agents are well known tools in the prevention and control of disease. Biological therapy will doubtless be replaced eventually by chemo-therapy, for through the activities of the biochemist and the organic chemist the structure and composition of immune substances and immunizing agents will be determined and subsequently synthesized outside the body. Already some of the vitamins and hormones have been synthesized and specific chemical substances are available for the treatment of specific diseases. The chemist and physicist are destined to make important contributions to our understanding of the mechanism of immunity and the composition of immunizing substances.

Still another factor that has played a part in the public health progress of the past 60 years has been the work of the statisticians. They have determined death rates and their trends. They have determined specific death rates for every cause of death and have analyzed these rates by age, sex, nativity, color, racial origin, occupation, economic status, religious affiliation, ward of residence, illiteracy and various other factors. In this way, a vast amount of epidemiological information has been assembled and utilized in planning the public health campaign. It has meant that the available funds could be spent more wisely and effectively.

Still another factor which has played a significant but unmeasurable rôle in the public health progress of the past 60 years has been the great campaigns of personal and popular health education. These campaigns have dealt with hygienic living; with the need for immunization against diphtheria, typhoid fever and smallpox; with the requirements of an adequate and properly balanced diet; with the importance of consuming milk in adequate amounts, especially pasteurized milk; with pure water; with proper excreta disposal; with the importance of controlling flies, mosquitoes and other insects as well as rodents; with the importance of dental care and early diagnosis in the detection of tuberculosis; with prenatal hygiene, infant and child hygiene; with the abatement of housing evils and atmospheric pollutions; with the importance of detecting and eliminating physical defects and the desirability of periodic, competent medical examinations. Campaigns of education have been waged against cancer, organic heart disease, the genito-infectious diseases and various other important human maladies. These campaigns have been waged in the public press, through other printed material, through lectures and demonstrations, through classes and through the aid of the public health nurse in the home and clinic. Attending physicians at clinics have frequently aided in this program of enlightenment. The public schools have been literally bombarded with health educational material, and the curriculum has been modified to include instruction in the essentials of healthy living. Such a campaign, conducted on so gigantic a scale, and one which has been so persistent must have had some effect, even though its magnitude is not measurable. Its potential value is appreciated by every progressive health officer and public health worker.

Since the tools of public health education consist of the printed and spoken word, pictures and demonstration material, and the intelligent use of scientific information coupled with a knowledge of mass psychology, this significant contribution to public health progress may also be considered an aspect of environmental control.

It is relatively simple to account for the great progress in the control of the intestinal and insect-borne diseases through the more effective control of the environment. It is also a simple matter to account for the control of such diseases as diphtheria and smallpox through the extensive use of suitable biological products for prevention, diagnosis and treatment. How can we account for the remarkable progress against tuberculosis? For tuberculosis is a respiratory disease very largely, and there has not been available a specific biological agent for immunizing susceptible individuals or treating those who are ill. Recently, of course, the developments of new surgical technique have made it possible to place a diseased lung at rest, a practice which has proven even more efficacious in hastening the healing process than bed rest. It is important to remember, however, that much of the great progress against tuberculosis occurred before the advent of surgical aids in the treatment of this disease. Accordingly, it is important to look for other causes to explain this remarkable phenomenon.

There are very few diseases that are so intimately linked up with the vital resistance of the body as tuberculosis. The rise in the mortality from tuberculosis during the World War in Austria, Germany, England and France lends support to this view. Doubtless the improvement in all the environmental factors affecting health—such as more adequate and complete nutrition; safe water supplies; pasteurized milk supplies; clean, wholesome, safe foods; increased sewerage facilities; shorter working hours; better working conditions; vacations and rest periods; health education; better housing; and the improvement in general health and vitality

following the more effective control of other diseases—has had its beneficent effect on the prevalence and mortality from tuberculosis. This does not minimize the importance of the development of laboratory aids in the diagnosis of tuberculosis and of the establishment of tuberculosis clinics for the early diagnosis of the disease and of sanatoria and hospitals for the effective treatment of the disease. But it does indicate quite definitely that the more effective control of the environment has played a part, and in all probability a large part in the progress made against tuberculosis.

Recently[13] the *Journal* of the American Medical Association, quoting from a study by Georg Wolff on "Tuberculosis and Civilization," published in *Human Biology* for May, 1938, lists five of the possible factors that have reduced the mortality from tuberculosis in the last 50 years from approximately 300 per 100,000 population to 50 per 100,000 population. The factors enumerated are: (1) a specific factor; (2) an hereditary factor; (3) a social factor; (4) a population factor; and (5) a medical prophylactic factor. Of these, the social factor is considered the most important and the items enumerated under this heading include improvement in economic well-being; better housing; better nutrition; better working conditions; smaller families; and hygienic education. As noted above, these factors are aspects of the environment of man, the improvement of which has been a fundamental cause in his superior well-being.

Phenomenal progress in preventing disease and premature mortality has also been made among infants and pre-school children. It is therefore desirable to inquire into the factors that have been largely responsible for the saving of human life in these very vulnerable age groups. An analysis of the statistical data available points very definitely to the fact that the control of the environment has been the dominant factor. Dublin and Lotka[14] show that in New York City in 1872 the death rate from diarrhoeal diseases under 5 years of age was equal to 40 per 1,000 of the population under 5 years; whereas by 1931, the death rate from this cause was down to 1 per 1,000. This remarkable improvement in the control of diarrhoeal diseases in children is due to the better control of all the environmental factors involved as well as the introduction of more scientific feeding. The control of diarrhoeal diseases in children alone would account for much of the life saving that has been witnessed in this group. If to this factor be added the saving of human life due to biological products used for prevention, diagnosis and treatment, and the improvement in the robustness of children due to improved hygiene, the significance of an improved environment on human welfare becomes more apparent.

If the factors responsible for the diminution of infant mortality be studied, a similar conclusion results. Dublin and Lotka[15] show the trend in infant mortality by cause for the U. S. Birth Registration States of 1917 for the period 1917–1932. The authors conclude that "the great gain that has been scored in preserving infant life has been due very largely to our success in dealing with this one item of diarrhea and enteritis. A large number of factors have undoubtedly contributed to the great improvement which has taken place in the mortality from this disease. Among the contributing factors should be mentioned particularly the introduction of the compulsory pasteurization of milk and the increasing spread and the greater perfection of methods of refrigeration; the education of mothers regarding the proper feeding of infants; attention to cleanliness of food and the avoidance of unripe fruit; the improvement in the quality of public and domestic water supplies; and the general awakening to the menace of flies as carriers of disease."

If infant mortality is studied by months, it will be found that approximately 60 per cent. of all infant deaths occur during the first month of life, and most of these during the first week of life. These infant deaths are most closely associated with the lack of suitable prenatal and obstetrical care and have shown remarkable constancy in some cases, while in others the rates have actually gone up. Infant death rates due to syphilis, congenital malformations, influenza and pneumonia, premature birth, whooping cough and bronchitis and broncho-pneumonia have either remained stationary or have receded very, very slowly, while the infant death rate due to injuries at birth has actually increased. Only recently have the neonatal infant mortality rates begun to come down in those enlightened and progressive communities where special campaigns have been waged.

Finally, the practice of medicine has undoubtedly played a part in the splendid public health achievement of the past 50 or 60 years. Surgery, aided by antisepsis and asepsis, by x-ray photography and by advances in our knowledge of general physiology, has unquestionably saved the lives of countless thousands of ailing humans. It has also promoted the comfort and well-being of other countless numbers whose lives were not in jeopardy. Improvement in laboratory diagnostic techniques as well as the establishment of public health clinics and outpatient department services have promoted the early diagnosis of disease which in turn has made it possible to place the patient under prompt and effective treatment in many cases. Good nursing has also done its share in helping the

[13] *Journal, Am. Med. Asn.*, 111: 11, 1020–1021, September 10, 1938.

[14] *Loc. cit.*, p. 156.

[15] *Ibid.*, p. 163.

body recover a state of health after medical treatment had been provided. The conclusion that can be drawn from this exposition is that the great public health achievements of the past 50 years are the result of the joint efforts of engineers, social workers, physicians, dentists, nurses, statisticians, epidemiologists, health educators, public health administrators, chemists, physicists, sanitary biologists and doubtless many others. Public health progress is emphatically not due to the activity of any one professional group.

Now that many of the communicable diseases have been brought under control by the methods described in the previous section, and such diseases as organic heart disease, cancer, nephritis, arterio-sclerosis, diabetes and other degenerative diseases have assumed increasing importance because of their high mortality, it is interesting to inquire how further public health progress is likely to be made. It is obvious that in so far as focal infections and communicable diseases are associated with the etiology of the degenerative diseases, their early discovery and elimination through expert medical service is of great value. Unfortunately, the degenerative diseases and cancer affect the population during the later adult periods of life and are apparently the result of physiological derangements of the human mechanism, the causes of which are still unknown. Early diagnosis and effective medical treatment in these degenerative diseases of later adult life may be palliative, but as yet they have not been successful in prolonging life to any appreciable degree. In order to accomplish this desirable end it is necessary to know how and why the degenerative diseases have their onset and to determine the best methods of prevention and control. Why does the body grow old and show the well-known symptoms of degeneracy and decay? What takes place within the body cells when senescence occurs? What keeps cancer in check during the early years of life in most cases and what occurs in the body later on in the very same human beings? The answers to these questions can not be found in the public health or hospital clinics. The answers must be found in the research laboratories, through the work of chemists, physicists, biochemists, organic chemists, bio-physicists, physiologists and other highly trained men in the various fields of science. In other words, further progress in prolonging the average life span of man at birth must depend on the significant contributions emerging from the various research laboratories.

At the present time, the evidence seems clear that those who reach the mature age of 80 years or more have usually come from long-lived parents. Such people seem to be able to overcome the hazards which are frequently fatal to those of shorter-lived ancestry. Heredity seems to play a far more important role in determining longevity than many of the factors normally regarded as significant. The effect of heredity on longevity is indicated by the data in Table 5.

TABLE 5

EFFECT OF PATERNAL HEREDITY ON LONGEVITY OF SONS[16]

Age of son at death, in years	Per cent. having fathers who died at age 80 or over
Under 20	24
20–39	21
40–59	27
60–79	38
Over 80	46

Great emphasis is being placed in the current public health campaign on the control of the genito-infectious diseases and pneumonia. Control, however, in these diseases is also based on the use of certain laboratory procedures for diagnosis, and on either chemo or sero therapy. It is apparent therefore that suitable control of the environment, including health education, also plays a rôle in the control even of these diseases.

The preceding analysis has brought out, I believe, the significance of the more effective control of the environment on the prevention of disease and premature mortality and on the prolongation of the average life span at birth. Coupled with a declining birth rate and with the restrictions that have been placed on immigration, the population of the United States has been growing older. This is evident from the larger proportion of the population now found in the later age groups. Older people must have and insist upon having a comfortable environment. Accordingly, the public health movement of the immediate future is destined to see greater emphasis on the comfort and convenience of man as well as a continuing emphasis on the prevention and control of disease. The former will undoubtedly include air conditioning, noise abatement, improved housing, smoke abatement, clean streets, parks and recreation centers, abatement of nuisances due to odors and unsightly conditions, stream purification and other items that fall within the realm of activity of the public health engineer. It would seem therefore that the importance of the public health engineer in organized community life is destined to increase rather than diminish.

SCIENTIFIC EVENTS

THE CONVERSAZIONE OF THE ROYAL SOCIETY

THE Royal Society held the first of its two annual conversaziones in its rooms at Burlington House, London, on May 24, when as usual a number of exhibits were displayed.

The London *Times* states that prominent among the

[16] *Ibid.*, p. 139.