*Airborne infection is once again a matter of considerable theoretical and practical significance in public health. The symposium which follows considers these in terms of research and application with particular attention to the diagnostic laboratory and the hospital. Furthermore, attention is called to the Committee on Laboratory Infections and Accidents of the American Public Health Association and its desire to learn about laboratory illnesses. New approaches to tuberculosis and other important infections are emphasized.*

# AIRBORNE INFECTION: HOW IMPORTANT FOR PUBLIC HEALTH?

## I. A HISTORICAL REVIEW

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THE popularity of airborne infection as an important concept in public health has fluctuated widely over the past 100 years. Once universally accepted, it then was rejected. In the past 30 years, a resurgence of interest and a more sophisticated scientific evaluation of evidence have led to the establishment of a sound theory of airborne infection of great importance to public health.

Before the beginning of the bacteriological era, airborne infection was the commonly accepted view by professional persons and laymen alike. Miasmas, meaning noxious vapors, and malaria, meaning bad air, illustrate this point. With the establishment of the germ theory of disease, and particularly with the work of Lister, the concepts of contact and droplet infection became dominant. Airborne infection was discarded as a significant mode of spread of disease for almost half a century.

In the early 1930's, however, an engineer at Harvard, William F. Wells, challenged this view both with laboratory demonstrations of the survival of microbial aerosols in exposure chambers and with practical field trials of ultraviolet irradiation for the control of measles in schools. A number of other workers, notably O. H. Robertson and J. E. Perkins in this country, and a large group in Great Britain, extended the concept to influenza, epidemic respiratory disease, and streptococcal infections among troops in training. Throughout World War II, and for some years subsequently, field trials were conducted in schools, hospitals, and military barracks testing the effectiveness of ultraviolet irradiation, of glycol and other disinfectant vapors, and of dust suppression. While some of these studies showed effects suggesting that airborne infection played a partial role, other well-controlled studies failed. Interesting theoretical points were discovered, but few if any practical applications were developed. The challenge to the dominance of droplet and contact infection for the common contagious and respiratory diseases did not succeed.

During the past 15 years radical changes have occurred in the prevailing concepts of airborne infection. Systematic epidemiological studies, supported by extensive laboratory studies in experimental animals and human subjects, have provided the basis for a sound theory of airborne infection. Certain naturally occurring diseases are now generally recognized as being airborne. These include: psittacosis, Q fever, histoplasmosis, coccidioidomycosis, inhalation anthrax, meat packer's brucellosis, and primary pulmonary tuberculosis. In addition, infection by inhalation of microbial aerosols has been shown to be a major hazard in research laboratories. Certain procedures involving highly infectious agents are notoriously dangerous. These include: intranasal instillation into animals, grinding of tissues in a blender, or concentrating in a centrifuge. Extensive precautions against aerial contamination are now standard practice in laboratories.

The particle size of microbial aerosols is a major factor in the occurrence of airborne infection whether natural, accidental, or experimental. Small particles, less than about 5 microns in diameter, pass through the nose and pharynx, down the trachea into the far reaches of the lungs to the terminal bronchioles and alveoli. Many of these small particles are trapped there, beyond the point where ciliary action of the bronchial epithelium can remove them. In contrast, particles larger than about 5 microns are trapped in the nose and throat or elsewhere in the respiratory tract and cannot reach the alveoli.

Experimental studies have shown that the number of small particles necessary to infect through the alveoli is very small, often ten organisms or less, whereas the doses necessary to infect with larger particles through the upper respiratory tract are uniformly great, often 1,000 to 10,000 organisms or more.

Present concepts of the portal of entry of respiratory infections have been sharpened over the vague and general views formerly held. No longer is it sufficient to say the portal of entry is the "nose" or the "alimentary tract." Now it is necessary to specify the exact locus of invasion of tissue within the respiratory tract. Diseases arising in the alveoli of the lung—psittacosis, Q fever, the pulmonary mycoses, and primary tuberculosis—are intrinsically and exclusively airborne infections. They arise only from the inhalation of extremely fine particles. On the other hand, diseases which arise in the nasal mucosa, on the tonsils, or on the respiratory mucosa of the upper respiratory tract such as diphtheria, streptococcal pharyngitis, pertussis, measles, or influenza can result from contact, or from droplets, or from the inhalation of large particles. Airborne infection may play a role in the spread of these diseases, but so also does contact. Discrimination between these two modes of spread is often difficult.

In line with these modern theories, airborne infection takes on new and highly specific importance for public health. Instead of worrying about the installation of expensive ultraviolet lights or glycol vaporizers in places of public congregation, now it is important to prevent the creation of infective aerosols. Strict discipline is necessary in meat and poultry processing plants to prevent brucellosis, Q fever, and psittacosis. Great care must be taken in cleaning out chicken coops, belfries, or caves where bird or bat droppings have created conditions favorable to the growth of Histoplasma capsulatum. At military bases or other institutions in the Southwest, appropriate planting of grass and use of other means of dust control are essential to prevent airborne infection with coccidioidomycosis.

Indubitably the most important naturally acquired airborne infection is primary pulmonary tuberculosis, although the full significance of this concept is not generally recognized by public health workers and practicing physicians. The pathogenesis of the disease clearly points to the alveolus as the portal of entry. The only reasonable route whereby the tubercle bacillus can reach the alveolus is by inhalation. The studies of Wells and Lurie in rabbits exposed to artificial aerosols and of Riley in guinea pigs exposed to natural aerosols in a tuberculosis hospital confirm this theory. Airborne infection accounts for all of the known epidemiological characteristics of the disease, such as the frequent absence of spread of infection to members of the household and even to marital partners of sputum positive cases. The former popularly accepted, but basically vague, concept of spread by prolonged intimate contact is not adequate to account for the epidemics of tuberculous infection that are being described with increasing frequency. Clearly a certain few open cases of tuberculosis serve as dangerous spreaders, whereas the great majority of cases remain relatively innocuous.

The implications of the theory of airborne infection of tuberculosis to public health workers are serious. A careful reappraisal of priorities in the tuberculosis control program is indicated. Instead of emphasizing routine examination of contacts of every newly reported case of tuberculosis, emphasis should be given to examination of contacts of source cases with positive sputum. The careful epidemiological investigation of all contacts of newly reported active cases in children and young adults and indeed of any case where primary infection is detected among close contacts deserves highest priority. The occurrence of a clinically manifest case of tuberculosis in a child should be treated as an epidemic emergency because it almost certainly means that a recent spread of infection has occurred in the community and other cases are probably in existence and should be discovered as soon as possible.

Finally, it should be universally recognized that the scientific principles now so clearly established for natural airborne infection provide, in large measure, the scientific bases for the theory of biological warfare. Much of the scientific information upon which the theory of airborne infection is based was derived from the extensive laboratory investigations performed at Fort Detrick and other military installations during and subsequent to World War II. This work is continuing. Public health workers must realistically face the problems of civil defense and recognize that essential to planning defense against biological warfare is an understanding of the scientific principles of airborne infection.

## BIBLIOGRAPHY

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