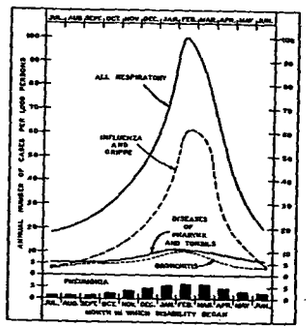
from the seasonal picture of airborne contagion, are such extrinsic factors as rate of turnover of personnel, and the marked susceptibility of the recruit as compared with permanent personnel[12] as shown (see Fig. 2) by studies of military personnel housed in barracks. These extraneous variables and the factor of contact infection (direct spray) tend to complicate any evaluation of the effectiveness of air sanitation for elimination of micro-organisms in droplet-nuclei and droplet-dust. Thus, control measures may eliminate consistently 90 percent of airborne organisms in laboratory tests, but may not effect a decrease in actual incidence of infection exceeding 30 percent. Thirty percent may be the maximal reduction in infection possible by air treatment methods. The distinction should be clearly drawn, therefore, between the effectiveness of a procedure in laboratory tests



Occurrence of diseases causing disability for 8 consecutive days or longer in a group of 100,000 wage earners (10 percent women) in different industries.

Fig. 1.... Study of Average Monthly Frequency (1921–1926 Inclusive) of Specified Respiratory Diseases

and its effectiveness and applicability in actually reducing the incidence of airborne disease. On the other hand, recent studies suggest that inhalation of dust-borne bacteria is more important than direct inhalation of infectious droplets or droplet nuclei in the spread of respiratory tract infections.[13]

The following sequence of events has been postulated as occurring in a large proportion of intra-ward infections: (*a*) ejection of relatively large protected infective particles from patients; (*b*) rapid venting or settling of these particles so that those remaining airborne are in low concentration; (*c*) survival of infective particles to permit the accumulation of high concentrations on surfaces; (*d*) repeated reintroduction of infective particles into the air under the stimulus of ward activities or by air currents of the order of 50 fpm over the floor; and (*e*) extension of infective areas by air turbulence throughout the ward or hospital. The most important link in this probable infection chain has been demonstrated to be the reintroduction of particles into the air.[13]

Intensive studies on air disinfection have indicated two distinct control measures: (*a*) suppression of dust and lint, and (*b*) disinfection of droplet-nuclei. A third measure, control of relative humidity, is important. It has been shown that the viability of certain organisms sprayed into the atmosphere from a liquid suspension is dependent on relative humidity. The mortality rate of the organisms is very high at a relative humidity of 50 percent,[14] and decreases at humidities above and below this figure. It has also been reported that the influenza virus loses much of its virulence when the relative humidity is 50 percent.[15]

Well controlled, large scale tests of the various methods of air sterilization conducted in barracks[16, 17] have confirmed the importance of dust control in minimizing the spread of airborne disease, a consideration which has guided the practices of ventilating engineers for a number of years. The importance of the dust factor has been emphasized by many engineers, and has been convincingly demonstrated by subsequent bacteriologic studies aboard ships.

Treatment of floors and bedclothes with oil emulsions has proved effective in reducing bacterial dispersion by as much as 90 percent in Army barracks and station hospitals.[17] The incidence of acute respiratory infections was from 10 to 30 percent lower in barracks with oiled floors and bedclothes than it was in control barracks which received no special treatment. More recent studies, however, have yielded inconsistent results.

An emulsifying mixture, *Fizanol C* containing cetyl pyridinium bromide, when incorporated in an oil-in-water emulsion imparted a bactericidal action. Blankets treated with this emulsion became bactericidal and retained this property for as long as three months. The possibility of hypersensitivity of an occasional individual to bromide drugs should be borne in mind when exposing large groups to treated garments or blankets.[18]

No simple method for disinfecting droplet-nuclei has yet been devised. Under favorable laboratory conditions, propylene glycol in concentrations of 0.07 to 0.14 milligrams per liter, and triethylene glycol in a concentration of 0.0045 milligrams per liter were highly germicidal for most airborne bacteria in clean air when the relative humidity was between 40 and 60 percent.[19, 20, 21] A humidity of 50 percent, without the use of glycol vapor, has been reported as destructive to some bacteria. However, maximum rates of bactericidal action of triethylene glycol vapor will be secured at humidities between 20 to 50 percent.[21]

In a recent report on the effect of triethylene glycol vapor in air disinfection, it is pointed out that the rate of ventilation, as determined by the number of air changes per hour, is important and that continuous vaporization is needed to maintain effective concentrations of glycol vapor.[22] In the absence of an apparatus to measure the concentration of vapor in the room, a slight fog is an indication of adequate concentration. Absence of such a fog indicates a non-bactericidal concentration. The report stated: "However, under experimental conditions we have observed no apparent decomposition of triethylene glycol when temperatures up to 290 F were maintained at the site of vaporization, provided the vaporizing unit was designed so that heat was applied to liquid glycol only at the point of vapor formation. On the other hand, decomposition was frequently observed when the vaporizing temperature was raised above 290 F, or when liquid glycol was kept above 120 F for long periods of time. The precise nature of the decomposition products is as yet unknown, but they may well be irritant or toxic and their formation should be avoided. For this reason, it is felt that a limit of 290 F should be applied to the temperature employed in vaporization, and furthermore, that liquid glycol should not be heated above 120 F for long periods of time."

It was also recommended that vaporizers be adjustable to a wide range of output as measured by grams of liquid glycol vaporized per hour; for instance, from 0.5 g to at least 2.0 g per 1000 cu ft of volume treated, for small vaporising units. Such high rates secure bactericidal concentration in less than an hour. Each room should be furnished with a single small vaporizer, and one vaporizer should not be expected to handle a volume greater than 4000 cu ft. Apparatus for the production of glycol vapor, and an independent duct system for carrying this vapor and diluting air for large rooms or spaces, and unit type vaporizers for small spaces, have been described.[22] There is also available a device called the glycostat for the automatic regulation of glycol vapor in the air. This instrument has been calibrated to measure the degree of saturation of the air with glycol vapor by direct reading of the variations in the intensity of

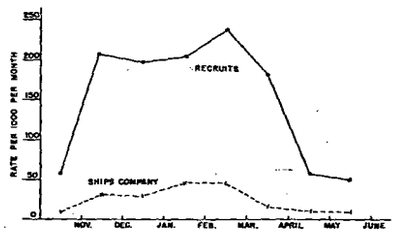


Fig. 2.... Monthly Incidence of Acute Respiratory Illness Among Naval Recruits and Ship's Company (Permanent Personnel)[1]

light reflected from the glycol condensing surface of the wheel of the instrument.[22]

Under practical conditions, particularly in the presence of dust in the air, glycol effectiveness is much reduced. The use of other chemical aerosols that have been tried is limited by their toxicity, odor, or destructiveness to fabrics and metals. A recently reported controlled experiment in the offices of the Metropolitan Life Insurance Company showed that under ordinary working conditions triethylene glycol vapor failed to reduce the number of airborne bacteria and the incidence rate of minor respiratory infections.[23]

Ultraviolet radiation of floors and upper air has been studied extensively at the Naval Training Center, Sampson, N. Y. In barracks housing naval recruits, hospital admissions for respiratory infections (mostly *catarrhal fever*) were 25 percent lower in a group of men exposed to ultraviolet radiation—2537 Angstrom Units, 1 to 7 ergs per (cm^2) (sec) at bed level—than they were in adjacent control barracks without ultraviolet radiation.[24]

A controlled study over a six-year period on the evaluation of ultraviolet radiation of sleeping quarters as a supplement to accepted methods of respiratory disease control has been reported.[25] The amount of radiation over the last two years of the period was believed to be about five times that recommended commercially. No significant effect on the incidence of disease could be detected in about 400 inmates during the six-year period. This conclusion may not be applicable to present ultraviolet equipment installed in accordance with manufacturers' recommendations. The data imply that air layers were not sufficiently mixed. However, more efficient mixing would have been obtained at the expense of increased circulation of dust and lint. Sources of ultraviolet radiation should be so situated as to protect the eyes of the occupants of the room from direct or reflected rays. A combination of ultraviolet radiation and dust control measures is believed to be more effective than either one of the two used alone, but the proof for this has yet to come.

There is no doubt that these methods will reduce the number of bacteria in the air of an enclosed space, but there is still considerable question as to whether they are practical measures for reducing the total number of respiratory infections among personnel, since exposure by contact is an important factor. Bourdillon and his group concluded that there is justification for attempting to reduce the load of airborne micro-organisms by the methods now available.[4] They have explored the properties of a number of compounds, and their conclusions are in agreement with those of American investigators.

The present status is admirably reviewed by the Committee on Sanitary Engineering of the National Research Council,[27] and by a subcommittee of the American Public Health Association.[5] Both committees believe that the problem of air disinfection is still in the experimental stage. Since knowledge of the effectiveness of glycol vapors has not kept pace with the development of vaporizing devices, there is real danger that commercial exploitation of the various devices may discredit the method and discourage careful research in this important field.[28] More experimentation is needed before a definite conclusion can be reached concerning its use in industry and public buildings.

VALUE OF AIR COOLING UNDER TROPICAL CONDITIONS

Although statistics are not at hand to indicate the deaths or retarded recoveries of patients due to lack of air cooling in ships operating in tropical waters, it is generally agreed among competent observers that high temperature and humidity are major factors in prolonging disability and increasing mortality of the sick and injured. Physiologic data obtained on healthy men, moreover, show the large loss of body fluids and the stress on the cardiovascular system in terms of increased pulse rate when these men are continuously subjected to high temperatures. Even at rest about 50 cc of fluid per hour are lost as sweat[29] through intact skin. In burn patients the difficulty, encountered in temperate climates, of maintaining fluid and electrolyte balance is tremendously augmented by the additional evaporative fluid loss in hot environments. Naval hospital ships having all wards, laboratories, and living spaces air cooled, represent a notable achievement in the control of environmental factors for the purpose of providing better treatment of patients, especially those suffering from extensive burns.

Patients who have such varied conditions as heart disease, thyrotoxicosis, shock from any cause, or severe hemorrhage, or those who have had an anesthetic, will invariably store heat when subjected to a hot humid environment. The gradient between the body surface temperature and the environmental temperature is such that loss by radiation is slight. The heat loss by evaporation in a warm humid environment is low whether the patient does or does not perspire. The