The Ventilation of Emigrant Ships

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As the chief officer of a medical inspection service, specifically appointed to examine all the immigrants entering Canada, with the idea of preventing the admission of persons suffering from acute communicable diseases, or from other diseases communicable but less acutely so, such as eye and scalp diseases, and with a view further, to allowing the landing of none not at the moment physically fit to earn a livelihood, my attention was early directed to the conditions existing on shipboard during a voyage, and their relation to outbreaks of disease which from time to time take on the character of an epidemic. During an active experience of over six years, I have naturally formed certain conclusions; one of the most positive of these is that conditions on shipboard in the emigrant quarters of many ships are such as demand radical changes, if very serious injustice to a poor, and, under the circumstances, helpless class of intending citizens of this or other new continents is to be prevented. To illustrate: I recall the S. S. "Montrose," tonnage 4,000, which arrived in Quebec, May 6, 1906, with 1,532 passengers; of these 124 were detained, 64 on account of conjunctivitis and 60 on account of trachoma, or one in every 12 immigrants.

When it is further understood that today at the great British and Continental seaports very complete equipment exists for the housing, inspecting, cleansing, and treating of thousands of emigrants at a time, (5,000 may be housed at Hamburg in suburban premises of many acres in extent, in separate buildings owned and equipped by the Hamburg-American Line) and that for days before arrival at these ports inspection has gone on at the borders and in the interior of Germany, Great Britain, Italy, and other countries, it is apparent that the emigrant going on shipboard at any of these ports today probably represents a higher absolute degree of immunity from disease than would a similar number of persons taken at random in any country in the world. It is evident, therefore, that when such persons have purchased passage on a transatlantic steamship, they have rights which the government of every progressive country should secure to them so far as is consistent with scientific knowledge and the actual practical difficulties of the situation.

* Read at 38th Annual Meeting of American Public Health Association, Milwaukee, September, 1910.

There has recently been published a very important report on "Steerage Conditions" by the Commission on Immigration appointed under an Act of the United States Congress passed February 20, 1907. The report reads as follows:

"Transatlantic steamers may be classed in three general subdivisions on the basis of their provisions for other than cabin passengers. These are: Vessels having ordinary or old-type steerage, those having the new-type steerage, and those having both. In order to make clear the distinction between these subdivisions, a description of the two, old and new, will be given.

"The old-type steerage is the one whose horrors have been so often described. It is unfortunately still found in *a majority of the vessels* bringing immigrants to the United States. It is still the common steerage in which hundreds of thousands of immigrants form their first conceptions of our country and are prepared to receive their first impressions of it. The universal human needs of space, air, food, sleep, and privacy are recognized to the degree now made compulsory by law. Beyond that the persons carried are looked upon as so much freight, with mere transportation as their only due. The sleeping quarters are large compartments, accommodating as many as 300 or more persons each. . . . The berth 6 feet long and 2 feet wide, with 2½ feet of space above it, is all the space in which the steerage passenger can assert a definite right. To this 30 cubic feet of space he must, in a large measure, confine himself. No space is designated for hand baggage. As practically every traveler has some bag or bundle, this must be kept in the berth. . . . At least two large transportation lines furnish the passengers in the steerage eating utensils, and require each one to retain these throughout the voyage. . . . .

"When to this very limited space of much filth and stench is added inadequate means of ventilation, the result is most unendurable. Its harmful effects on health and morals scarcely need be indicated. Two 12-inch ventilator shafts are required for every 50 persons in every room; but the conditions here are abnormal, and these provisions do not suffice. The air was found to be invariably bad, even in the higher enclosed decks where hatchways afford further means of ventilation. . . . . Considering this old-type steerage as a whole, it is a congestion so intense, so injurious to health and morals that there is nothing on land to equal it. That people live in it only temporarily is no justification of its existence. The experience of a single crossing is enough to change bad standards of living to worse. It is abundant opportunity to weaken the body and implant there germs of disease to develop later. . . Legislation, however, may complete what competition began.

"The new-type steerage may again be subdivided into two classes. The best of these follows very closely the plan of the second cabin arrangements; the other in some respects adheres to the old-type steerage. These resemblances are chiefly in the construction of berths and the location and equipment of dining rooms. . . . Staterooms contain from two to eight berths. The floor space between is utilized for hand-baggage. On some steamers special provision is made beyond the end of the berths for baggage. There are hooks for clothes, a seat, a mirror, and sometimes even a stationary washstand and individual towels are furnished. Openings below and above partition walls admit a circulation of air. Lights near the ceiling in the passage-ways give light in the staterooms. In some instances there is an electric bell within easy reach of both upper and lower berths which summons a steward or stewardess in case of need. . . . In spite of the less crowded conditions the air

is still bad. Steamers that were models in other respects were found to have air as foul as the worst. The lower the deck the worse the air. Though bearing no odors of filth, it was heavy and oppressive. It gave the general impression of not being changed nearly often enough."

While it is hardly necessary to say that with the marvellous evolution of naval construction today, whereby a great ocean liner transports its 2,000 or 3,000 human beings 3,000 miles in five or six days, the horrors of ocean voyages are yearly becoming a thing of the past, the quotations already given show how many vessels of the old type still exist with voyages of eight to fourteen days' duration. For instance, during the present year (1910) some 76 vessels have been engaged in bringing immigrants to Canada across the Atlantic, and not more than ten have other than the old-fashioned natural, air-duct ventilation.

In spite of this fact, it is a remarkable commentary on the thoroughness of European inspection that during three months, ending July 31, out of some 80,000 immigrants not more than 400 were detained at Quebec for all diseases not included in the acute contagions. The illustration already given, however, shows what would have happened with perfect certainty, had contagion accidentally been conveyed into the steerage quarters, on any except the largest and best-ventilated ships, if they were crowded as during the spring sailings, or even if they were not crowded. I have learned by personal observation, that when there is not a large number of passengers, two or three compartments only out of eight or nine were used during the voyage for the sake of economy of management.

It is apparent, of course, that no evidence of the serious effects of overcrowding on shipboard during a transatlantic voyage upon the spread of a chronic disease, such as tuberculosis, can be obtained; but we have unfortunately too much evidence of the high mortality from tuberculosis in the navy of different countries to question the extremely serious effects, not only upon the blue jackets, but also upon the 500,000 sailors of different countries who go down to the sea in ships. Thus, in a study of tuberculosis in the U. S. Navy by Surgeon General P. M. Rixey, M. D., in 1908, it is pointed out that for the five years ending in 1906, the German Navy gave a mortality from tuberculosis of 2.4 per 1,000, the British Navy of 3.2 per 1,000, and the U. S. Navy 5.6 per 1,000, or actually 4.9 in the latter during an eleven year period. Dr. Rixey quotes Assistant Surgeon Stitt of the "Wasp," who, after setting forth many of the well-known means by which the dissemination of tuberculosis takes place, goes on to say:

"Anyone who has studied the conditions prevailing on our men-of-war can understand the unfavorable conditions for consumptives when the cubic air space per man frequently falls below 300 cubic feet, and when even if the artificial means of ventilation provides for such deficiency,

proper conditions may not obtain by reason of the tendency to decrease the revolutions of the blower, notably by those in authority, to save coal, etc., but surreptitiously as well, by the men themselves closing valves to mitigate draughts or lessen the noises at night."

In this quotation we have summed up the essential features of the situation, and have fully illustrated its difficulties. That its difficulties have hitherto been and still are great on battleships, has been very admirably set forth in a paper presented at the Army and Navy Section of the meeting of the British Medical Association, held in London last July (1910), by Surgeon L. F. Cope of the Royal Navy, the subject of his paper being "Air and Ventilation in Modern Warships." Surgeon Cope points out that it is none too easy to obtain a constant supply of pure air on a modern warship; that the living space may be taken at about 200 cubic feet per man, that the distribution of air is difficult, and that the blue jacket likes to keep all vents closed. He points out that through a 15½ inch circular port with a hatchway near it, and a difference of 20° F. between the outer and the inner temperature, the air delivery on a calm day gives about 13,000 cubic feet per hour; that is, roughly, enough for four men. He then adds: "It is, however, apparent that when 150 live on a mess deck it is quite impossible to arrange enough ports and hatches to supply them with sufficient air by means of natural ventilation alone."

In modern warships this system has been replaced by fan ventilation. A typical ship of modern type has in all 62 fans ranging in size from 40 in. to 7½ in. in diameter, of which 7 are exhaust and 55 are supply fans. Inlets to the different quarters are provided on the basis of one louvred opening to every 1,000 feet of cubic air space.

Surgeon Cope gives the average of 100 determinations of carbonic acid ($C O_2$) under various conditions with the same average number of men with the following result:

1. Optimum conditions with all scuttles and hatches open and fans running everywhere	6.6	parts	per 1,000	($C O_2$)
2. With natural ventilation	9.0	"	"	"
3. With artificial ventilation only	8.4	"	"	"
4. With no attempt at supplying fresh air	13.0	"	"	"

It was found that all the living spaces where the men and officers live can be supplied by sirrocco fans 12½ in. diameter, with 4,000 cubic feet of air per minute, and that such an area could be properly ventilated where one fan is placed at each portion of the mess deck and supplied with air by a trunk running down from the upper deck. In winter the air was warmed in chambers with steam coils, but became dried to the disagreeable extent of having only 46% of relative humidity. So far no remedy of this condition has been attempted.

I have given briefly the chief facts in these experiments, first, because they are the first I have seen described anywhere relating to the artificial ventilation of a large modern vessel, and second, because they accord so closely with conclusions I have gradually been arriving at with regard to emigrant ships. Recently I went to Europe on a vessel of the most modern construction fitted up with fan ventilation, consisting of 15 inlet fans and 10 outlet fans. There were six decks, and the fan ventilation was supplied to the lower decks, the upper saloon quarters having natural ventilation. At different times I inspected the vessel with the captain and the ship's medical officer, and it was only in the sailors' quarters that the usual stuffiness was noted, and this was owing to the old habit of the sailors in shutting out fresh air. I returned home from the Continent on a twelve day ship, solely for emigrants, on which I was the only saloon passenger. On this voyage I was officially instructed to study the sanitation of the ship. It was a ship of 4,712 gross tons, with accommodation under British Board of Trade laws, adopted in the Canada Immigration Act, for 1,000 passengers, which number was slightly exceeded in the May voyage. On this voyage nine separate compartments contained emigrants, but with the small number on my trip, the largest number was 88 in 2,417 square feet of deck space, in compartment No. 6. With the legal allowance of 2 x 7½ feet, or 15 square feet of floor space with 7 feet height, the cubic air space of this compartment for each emigrant was about 200 cubic feet, which, on a previous voyage with 143 in the compartment, was reduced to about 100. There were the usual inlet and outlet ducts leading from the deck, with cowls set either towards or from the wind. During the whole voyage there were head winds, so that at from 10 to 11 knots an hour a strong wind was always blowing and the conditions were most favorable for ventilation.

The test apartment, compartment No. 6, held only 88 persons (young men), while its legal capacity was 143 or more. This apartment was on the lower deck, and had a floor space of 2,417 square feet. The ventilating duct was 16 feet long, and of 18 inches diameter; the funnel opening on the deck was 30 inches, with a capacity of 254 square inches, or 1.76 square feet.

June 30—Test No. 1, Wind W. W. & S.

Air velocity per anemometer	2,519 cu. ft. per 5 min.
Air velocity per anemometer	504 per min.
Air supplied per hour	55,696 cu. ft.
Test No. 2 (same day).	
Air velocity per anemometer	2,820 per 5 min.
Air velocity per anemometer	564 per min.
Air supplied per hour	59,558 cu. ft.

July 4—Test No. 3, 11 P. M.

Air velocity per anemometer	2,015 per 5 min.
Air velocity per anemometer	403 ft. per min.
Air supplied per hour	42,557 cu. ft.
Air for 88 persons	484 per capita
For complement of 143 persons	297 cu. ft.

July 7—Test No. 4, 4 A. M. Compartment No. 6.

Rate of air flow	2,950 per 5 min.
Velocity	590 per min.
Air supplied per hour	64,304 cu. ft.
Air supplied to 88 persons	732 cu. ft. per hour
Air supplied to 143 persons	452 cu. ft. per hour

July 1—Test of air flow Compartment No. 7 (upper deck).

Area 1,391 sq. ft., capacity 82 persons
Length of duct 8 ft. inlet 16 in. diameter, area 201 sq. in.

Velocity of flow	886 ft. per min.
Air supplied per hour	53,200 cu. ft.

A study of the tables makes it apparent that the average amount of air actually supplied, taking the two extreme tests, was 608 cubic feet per person per hour, with 88 present, or with the legal complement, 374 cubic feet per hour. During the voyage the polymeter readings for moisture remained between 65 and 75 per cent of relative humidity except on one stormy day.

To illustrate the results of the ventilation a number of tests were made on the carbonic acid present in the air, with the results shown in the tabulation given below. It will be noted that the results were obtained during the summer when the outer air was warm and could be introduced unheated without serious inconvenience, and at a time when the ventilation hoods were specially set into the wind to insure the largest amount of air possible. The tests were made in compartment No. 6, whose area has been given.

The amount of carbonic acid in immigrant quarters (Compartment No. 6):

Normal air contains 3 parts carbonic acid ($C O_2$) in 10,000 parts.

Test No. 1, 11 P. M.—With apparatus placed between inlet and outlet ventilator.
Amount of carbonic acid, 7.5 parts in 10,000 parts.

Test No. 2, 11:30 P. M.—With apparatus placed at side of compartment.
Amount of carbonic acid 10 parts in 10,000 parts.

Test No. 3, 4 A. M.—With apparatus placed same as in Test No. 2.
Amount of carbonic acid, 12 parts in 10,000.

If the estimate be made from these experiments for 143 persons, the number legally admissible to the compartment, the amount of carbonic acid would be proportionately greater per 10,000 parts.

Not only is it made apparent from the table that with the small number, relatively, present and the most favorable weather and wind conditions, the compartment hour by hour became increasingly foul, but a careful estimate made of the accumulating air pollution shows it has also something of a geometrical ratio of progression up to a point where an equilibrium is established between the polluting influence and the fresh air introduced.

But though it is true that the short residence on shipboard in an overcrowded apartment in the stormy weather of the spring, made more foul through seasickness, cannot be productive of the same constitutional evils as continued residence in unventilated quarters, yet the records of immigrant detentions on arrival at our seaports have shown that it is only necessary under such conditions to have a case of infectious disease present in a compartment, such as measles or ophthalmia, in order to have the infection disseminated throughout the whole compartment. Hence it is apparent that in the interests both of the steamship companies and of the emigrants, either one of two methods should be adopted for increasing the amount of fresh air available *per capita* in the sleeping quarters on board ship. These are: Increase of air space per person, or, increase in the amount of fresh air introduced. While the first method may or may not, for financial reasons, always be possible in practice, yet it is certainly possible, by mechanical appliances, to increase very greatly the amount of fresh air driven into a given cubic air space. What is urgently needed is the adoption on the older ships, and indeed even on some of the newer and smaller vessels, of mechanical fan ventilation.

The actual condition of a single ship which arrived in the St. Lawrence this year was as follows:

The ship left Rotterdam on June 13, and arrived at quarantine on the 26th. One case of measles occurring on June 14, was immediately isolated with the members of the family to which it belonged. In the compartment where the case occurred there were 279 individuals, married persons and members of families. The compartment consisted of two decks connected at each end by a small stairway, and these compartments were ventilated by means of these stairways and by a portion of the hatches being left open during fine weather. The beds were set up all around the sides and the eating tables occupied the centre of each deck. On the morning of the 26th (exactly 13 days after exposure on the 13th, when the first rash appeared), several cases of measles were discovered by the ship's surgeon, who continued to find others every hour of the day, until on arrival he reported 21 cases. By 9 P. M. a dozen more were

discovered by the quarantine officer. All the 279 passengers were landed at quarantine. These persons comprised 51 families. Of the number, there were 174 children 18 years and under. The total number of cases was 71. 36 families developed cases; 15 families developed no cases, but the members of these 15 families were all grown up or had had measles recently. It is clear, then, in the condition under which these people were associated in the compartments, that every non-immune person was infected with measles within the short period of 24 hours.

If such is actually the situation, and its truth might be further abundantly illustrated by actual occurrences during the past six years, the fact that the increasing competition between steamship companies may gradually result in adequate remedies being supplied can hardly excuse inaction on the part of those responsible for seeing that what has just been illustrated should no longer be allowed to continue.

As in much of our sanitary progress, if not indeed in all of it, scientific certainty as to our facts is the first essential, so it is especially desirable that the public be informed that progress in this matter will inure to its benefit, and that there will be an elevation of the plane upon which the great commercial and industrial corporations carry on their business.

In the present matter, however, all these several stages have already been reached, both in the United States and in Canada; and from my personal investigations I am convinced that most European countries have likewise realized their duty in relation to the transportation of emigrants. Hence I am convinced that the time and occasion have arrived for making much more scientific and definite the regulations which govern the transportation of emigrants on shipboard, by insisting through boards of trade in the several countries and through immigration authorities that the essential sanitary requirements, which the competition for high class travel has brought about, in the ventilation and other sanitary conveniences of transatlantic vessels, be extended to all ships bringing immigrants to America.

Very stringent regulations are enforced regarding the moral conduct of ship's officers and men in their relation to emigrant passengers; it is surely high time that the sanitation of the vessel in relation to its effect upon their physical well-being be equally cared for.