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# Comparative Epidemiological Analysis of Sanitation and Immunization in the Control of Typhoid and Cholera

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## *Introduction*

In public health practice, the selection of control measures for enteric infections such as typhoid and cholera is a rather difficult task. There are several measures available, the most important of which are sanitation and immunization, or combinations of these in varying proportions. To arrive at a control program which will produce the best results for the efforts and resources invested, there is need for strict quantitative measurement of the inputs (costs, etc.) and outputs in terms of improvements in health and the economy of the community.

Epidemiological models help in forecasting the effects of various control programs and in comparing their relative cost effectiveness.

## *Epidemiological Models*

Epidemiological models facilitate an understanding of the way in which a disease develops in a community and the way in which this development process is modified by different types of intervention.

In the general structure of both our typhoid[1] and cholera[2] models, the population is divided into a number of subgroups identifiable in the natural courses of the diseases (see References 1 and 2 for Flow Charts).

With our present knowledge of the disease and its natural history, it is possible to estimate the probabilities of transition from one subgroup to another and, wherever relevant, the duration of stay in any particular state. The number of new cases at any point of time is considered to be the result of an interaction between the existing numbers of susceptibles and infectives and the force of infection operating at that time. The force of infection depends on a number of biological and socioenvironmental factors and varies from one community to another and from year to year. It is difficult to enumerate all the components that go to make up a "force of infection." However, expected distributions and trends of the disease assuming varying forces of infection are compared with observed distributions, and after a few trials and adjustments it has been possible to arrive at estimates which appear to be sufficiently precise to describe observed phenomena.

### Epidemiological Model for Typhoid

The purpose of this model, which is fully described elsewhere,[1] was to assist public health administrators in the choice of appropriate control programs. In simulating the effects of sanitation and immunization, population coverages as well as costs of such programs were varied, and the relationship between cost and effectiveness was studied.

We have attempted to predict the long term effect of privy construction and immunization in one country, Western Samoa, and have shown that there is little difference between these two measures either in cost effectiveness or cost benefit. However, any change of the cost, e.g., of immunization by use of quadruple (diphtheria, pertussis, tetanus, and typhoid fever)[3] vaccine instead of monovalent typhoid antigen, will give, from the cost-benefit point of view, advantages to immunization. Similarly, lowering the cost of privy construction, e.g., through voluntary labor, may bring out sanitation as a better strategy. Further, sanitation will emerge as the most cost-effective strategy if its influence on other enteric infections is considered. Optimal strategies would depend on the situations, but evaluation of alternatives using a computer will identify these.

For use when computer facilities are not available, simple nomograms have been developed for determination of the approximate cost-benefit balance point of immunization (or sanitation) programs.[4] If the incidence of infection and the costs of treatment and immunization (or sanitation) are known, the nomogram will show whether the proposed measure is economically beneficial.

### Epidemiological Model for Cholera

The purpose of this model, described elsewhere,[2] was also to help in planning appropriate control measures.

The model of cholera differs from that on typhoid in that it deals not only with endemic situations but also with epidemic outbreaks and seasonal variations. Epidemic patterns, as in the case of explosive waterborne outbreaks lasting for a period of time, are characterized by a temporary rise of the force of infection to a very high level. In this way, an outbreak of short duration but of high intensity is produced, and, by varying the level of changes in the force of infection, different patterns and types of outbreaks can be simulated.

If the choice between sanitation and vaccination may depend on the circumstances in typhoid control, the superiority of sanitation in cholera control is obvious in every situation. This is due mostly to the fact that while typhoid vaccine gives a high degree of immunity which lasts for 5 years or so, cholera vaccine is a poor antigen with a low degree of protection, lasting for 6 months or so.

## *Selection of Control Strategy*

Cost effectiveness and cost-benefit analysis based on long term forecasts provided by epidemiological models provide a scientific basis for deciding on appropriate strategies for control of cholera and typhoid. The parameters, and consequently the solutions, could depend on the circumstances. Although the models are based on simplified assumptions and approximate estimates they could nevertheless be useful in scientific decision making. As another example we can quote the attempt made to study the problem of resource allocation in public health using tuberculosis control as a case study.[5]

## *Discussion and Conclusions*

Cholera and typhoid, like other enteric infections, results from unfavorable environmental conditions. It is therefore not surprising that our analysis has shown that in the control of these infections sanitation has the most important role to play. If, in typhoid, immunization has some merits because the vaccine is cheap and highly effective for a long time, this is not the case with vaccines for other enteric infections. Sanitation has a cumulative effect which is not the case with vaccination. Moreover,

sanitation protects against most enteric infections while vaccination is still strictly disease-specific.

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# Soiled Disposable Diapers: A Potential Source of Viruses


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## *Introduction*

The average production of solid waste in the United States is 5.3 pounds per capita per day, or more than 300 million tons annually.[1] Although it is recognized that the disposal of solid waste is fundamentally a health problem,[2] the biological threat to health caused by human pathogens carried by or in association with the waste has not been explored. Excreta and products of animals have long been a part of municipal solid waste. The appearance of soiled disposable diapers in this waste creates a situation that increases the amount of human excreta in solid waste, and thus adds another dimension to the health hazard of the solid waste. Viruses, in particular, are a source of concern since babies are the most effective carriers of enteroviruses and have generally been immunized with live polio vaccine. In an early study that we conducted in 1971 on the occurrence of viruses in municipal solid waste, the expected enteric virus density in this waste was calculated to be about 32 virus units per 100 gm.[3]

The present investigation describes the amount of soiled disposable diapers found in municipal solid waste, the amount and types of enteric viruses found in these diapers, and the implication to public health of their appearance in solid waste.

## *Materials and Methods*

### Sampling of Waste and Detection of Virus

Municipal solid waste collected from an area in Cincinnati, Ohio (area A), and from an area in northern Kentucky (area B) was delivered to a pilot laboratory where the waste was separated. The diapers picked from the waste were placed in sterile plastic bags and brought to the laboratory for processing. A 5-gm portion of fecal material was removed from each disposable diaper and concentrated for virus by methods described elsewhere.[3-6]

## *Results and Discussion*

### Amount of Soiled Disposable Diapers in Municipal Solid Waste

A total of 8.2 tons of waste was separated. The results obtained from the studies showed that, by wet weight, 0.6 to 2.5 per cent of solid waste was soiled disposable diapers (Table 1). Because approximately 33 per cent of the diapers contained fecal matter and each pound (wet weight) of feces-soiled diapers contained an average of 60 gm of feces, the average amount of fecal matter in solid waste was calculated to be about 0.2 gm per 1 pound (wet weight).

### Isolation of Viruses from Fecally Contaminated Disposable Diapers

Of the 84 fecally contaminated disposable diapers tested, nine contained viruses (Table 2). Viruses were detected in 15 per cent and 2.9 per cent of samples from area A collected during February and April, respectively; 16.7 per cent of samples from area B contained viruses during July.

Poliovirus 3 was recovered from disposable diapers in both sampling areas and echovirus 2 was found in two