similar studies. On the other hand, no amount of statistical help and expert knowledge can produce valuable results from data based on inaccurate observations. The methods used in the field observations in this study have therefore been presented at some length in the hope that their description, including the difficulties and pitfalls involved, may be of some help to other workers in this field.

Diarrhoeal Disease and the Environment *

by D. J. SCHLIESSMANN, Sanitary Engineer Director; Chief, State Aids Section, Technology Branch, Communicable Disease Center, Atlanta, Ga., USA

The consistent and rather dramatic decline in diarrhoeal disease morbidity and mortality rates in the USA and in certain other areas of the world during the past century has been attributed largely to improvements in environmental sanitation. Most public health workers currently do not question the propriety or desirability of environmental controls, but rather the priority that should be given to them relative to nutritional and medical care needs in newly developing areas with an acute diarrhoeal disease problem. Nevertheless, occasional doubts are still voiced as to the importance of environmental control for prevention of diarrhoeal disease, such as those presented in the Weir report. These doubts prevail despite evidence of decline in diarrhoeal disease consequent upon sanitary improvement and general acceptance that environmental sanitation measures are prerequisites for the control of diarrhoeal disease and enteric infections.

For the purpose of this report, environmental control may be defined broadly as the control of those factors in man's physical environment which influence the spread of disease or result in man's discomfort. Further, the assumption is made that factors relating to control of diarrhoeal disease include ideally (1) provision of a safe, adequate water supply under pressure within each home; (2) provision of sanitary methods for excreta disposal within each dwelling, and prevention of faecal pollution to ground and surface water supplies; (3) elimination of household and neighbourhood contamination of soil; (4) prevention of access of vectors—namely, flies and hosts of schistosomes—to human or animal faeces; (5) provision of housing with adequate space to prevent excessive crowding and absence of rodents, vermin, and domestic animals; and (6) sanitary controls governing production, processing, storage and consumption of milk and food.

It should be emphasized here that the needs for total environmental control is universal. In highly developed areas a majority of the basic needs may have been met and such new problems as air pollution and protection from radioactive materials created. While development of environmental controls in such circumstances may be exceedingly complex, they are, in reality, less difficult to achieve than the basic environmental controls needed in newly developing areas of the world. In the latter areas, the complexities of extending sanitation programmes so as to use local supplies, materials and labour are further complicated by financial problems and the various customs and traditions of the inhabitants.

Studies to determine the precise relationship between environmental sanitation and diarrhoeal disease have no doubt been limited by two factors: first, the general acceptance of the importance of environmental sanitation for control of the disease; and, secondly, the difficulties involved in the evaluation of the effect of single or multiple environmental factors on reduction of diarrhoeal disease. Therefore, before reviewing specific studies pertaining to evaluation of the significance of individual environmental controls for prevention of diarrhoeal disease, a few generalizations may be made.

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* Note submitted to the WHO Study Group on Diarrhoeal Diseases, November 1958.

a Though the importance of good nutrition and medical care is acknowledged readily, they are not considered germane to this report.


c American Public Health Association (1955) Control of communicable diseases in man, New York
In general, the highest morbidity and mortality rates are experienced in those populations having a lower level of environmental sanitation than the national or community average. For example, within the USA diarrhoeal disease mortality rates are one to six times higher than the national rate in those States where the level of environmental sanitation falls below the national average. In individual States, extreme ranges in mortality rates are observed in certain ethnic, occupational or income groups possessing a lower level of environmental sanitation than the State average. Within individual communities, the highest rates are observed in areas lacking sanitary facilities. In the years 1946 through 1949, the author found the death-rate from diarrhoeal disease in the population under two years of age to be six times higher in slum areas than in well-sanitized areas in a city of approximately 300 000 in the USA.

Water

The documented evidence of the importance of safe municipal water supplies in controlling and preventing water-borne outbreaks of typhoid fever and cholera is unquestionable. Similar evidence, however, on the effect of such developments on reduction of diarrhoeal disease morbidity and mortality is largely presumptive. This is partly because installation of safe community water supplies has commonly been associated with additional environmental controls. Acknowledging limitations in the data on the importance of water per se for control of diarrhoeal disease, it can at least be said that reductions in diarrhoeal disease have usually resulted either from water supply improvement or from the chain of events created by this measure.

Various explanations have been suggested for failure to obtain parallel rates of reduction of diarrhoeal disease and typhoid fever with installation of municipal potable water supplies. This may be attributable to the various modes of transmission and to the multiplicity of infectious and non-infectious causes of diarrhoeal disease. In areas of high endemicity, there is substantial evidence that the primary cause of acute infectious diarrhoeal disease is infection with a species of the genus *Shigella*. Whereas the typhoid bacillus and the cholera vibrio have been shown to remain viable for a considerable time outside the human host and in water, the bacillus of *Shigella* dies off rapidly (in a matter of hours). This, together with the limited number of documented outbreaks of water-borne shigellosis (bacillary dysentery), is suggestive of the somewhat limited role of drinking-water in the spread of this disease.

Observations in California by Watt et al. and in Korea by the present author during the fall of 1951 revealed that diarrhoeal disease morbidity rates varied significantly with the quantity of water available for personal hygiene. This observation, together with substantiating data of Hardy & Watt that the primary mode of spread of shigellosis was from person to person, suggested that the quantity of water available for personal hygiene should be considered in plans for prevention of diarrhoeal disease. Since 1950, a number of studies have been conducted to determine the relationship between water availability and incidence of disease.

Results of studies in California, Guatemala, Georgia and Kentucky on prevalence rates of *Shigella* by selected sanitary facilities are summarized in Table 1. Studies in migratory labour camps in California in 1952 and 1953 showed that the *Shigella* infection rate in children 10 years of age or under living in dwellings with water outside was approximately twice that observed in children having water under pressure inside the dwellings. Beck et al. reported that analysis of data strongly suggests that organisms of the genus *Shigella* cause the major portion of the diarrhoeal diseases in the communities studied..." and it was concluded that "the high rates in Guatemala (1955 and 1956), as in the United States, were associated with the lack of sanitary facilities, with poor housing, with limited water supply, and with poor personal hygiene."

Studies by Stewart et al. showed that the prevalence of *Shigella* infections in families living in dwellings with water sources off the premises was approximately one-and-a-half times greater than in families residing in dwellings with water sources outside dwellings but on the premises. The studies also reported no significant differences in infection

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rates between families having city water and those utilizing open, dug wells, although the dug wells were subject to pollution. While the possibility of water-borne Shigella infection was acknowledged to be far greater from the well water than from the city water, it was concluded that “the bacteriological purity of water as measured by type, city or well, did not influence the infection rates”.

Investigations conducted in coal-mining camps in Eastern Kentucky in 1954-56 showed a significant, inverse correlation between water availability and the prevalence of Shigella, the incidence of Ascaris infections, and diarrhoeal disease morbidity (Table 2). In these studies, the Shigella infection rate in pre-school children living in dwellings with water available outside the residences was more than two times the rate in children residing in dwellings with water inside. Similarly, diarrhoeal disease morbidity rates and incidence of Ascaris infections among people living in dwellings with water of among people living in dwellings with water outside the premises were approximately one-and-a-half times greater than the rates experienced by people residing in dwellings with water inside.

Where the source of water supply was outside the dwelling unit, Shigella and Ascaris infection rates were comparable, regardless of water source location in relation to the premises. As in the Georgia studies, transmission of enteric pathogens by polluted water could have occurred easily. Bacteriological examination of many private water sources, including some community supplies, showed evidence of faecal contamination. There were, however, no instances in which water quality could be implicated in disease outbreaks or Shigella prevalence. Since it was concluded in these investigations that infection with the genus Shigella was the primary cause of diarrhoeal disease in the study populations, the observations on significance of water quality in the study do not conflict with the general view that water-borne outbreaks of shigellosis are infrequent.

Excreta disposal

It is generally acknowledged that reductions in typhoid fever as well as in helminthic and protozoal infections follow installation of sanitary excreta disposal facilities. While precise data are not available, extensive privy building programmes in the USA and in several other countries have contributed to the decline of typhoid fever and hookworm infection. A report of the International Cooperation

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TABLE 1
PREVALENCE RATES FOR SHIGELLA BY DATE AND SELECTED SANITARY FACILITIES IN KENTUCKY, GUATEMALA, CALIFORNIA AND GEORGIA

<table>
<thead>
<tr>
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<tbody>
<tr>
<td></td>
<td>Number of cultures</td>
<td>Percentage positive</td>
<td>Number of cultures</td>
<td>Percentage positive</td>
</tr>
<tr>
<td>Water and flush toilet inside dwelling</td>
<td>5 017</td>
<td>1.1</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Water inside dwelling, privy outside</td>
<td>2 195</td>
<td>2.4</td>
<td>1 451 d</td>
<td>6.3</td>
</tr>
<tr>
<td>Water and privy outside dwelling</td>
<td>3 994</td>
<td>5.9</td>
<td>891 e</td>
<td>9.4</td>
</tr>
<tr>
<td>(Water on premises)</td>
<td>1 988</td>
<td>5.8</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>(Water off premises)</td>
<td>2 006</td>
<td>6.0</td>
<td>—</td>
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</tr>
</tbody>
</table>

a Cultures from pre-school children
b Cultures from children 10 years of age and under
c Data from Stewart et al. (1955) Amer J. trop. Med. Hyg., 4, 718
d Facilities (including toilet) in more than 50% of dwellings
e Facilities in less than 50% of dwellings
TABLE 2
REPORTED DIARRHOEAL DISEASE MORBIDITY RATES, SHIGELLA INFECTIONS IN PRE-SCHOOL CHILDREN, AND PERCENTAGE OF POPULATION INFECTED WITH ASCARIS ACCORDING TO SELECTED SANITARY FACILITIES IN KENTUCKY, 1954-56

<table>
<thead>
<tr>
<th>Sanitary Facilities</th>
<th>Morbidity rates</th>
<th>Shigella prevalence</th>
<th>Ascaris incidence</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>0-4 years</td>
<td>All ages</td>
<td></td>
</tr>
<tr>
<td></td>
<td>PME a</td>
<td>Rate b</td>
<td>PME a</td>
</tr>
<tr>
<td>Water and flush toilet inside dwelling</td>
<td>5 040</td>
<td>428</td>
<td>33 961</td>
</tr>
<tr>
<td>Water inside dwelling, privy outside</td>
<td>2 200</td>
<td>829</td>
<td>14 821</td>
</tr>
<tr>
<td>Water and privy outside dwelling</td>
<td>3 881</td>
<td>1 140</td>
<td>21 602</td>
</tr>
<tr>
<td>(Water on premises)</td>
<td>1 900</td>
<td>953</td>
<td>10 883</td>
</tr>
<tr>
<td>(Water off premises)</td>
<td>1 981</td>
<td>1320</td>
<td>10 719</td>
</tr>
</tbody>
</table>

- Person-months experience
- Rate per 1000 per annum

Administration\(^k\) attributed the reduction in the diarrhoea and enteritis death-rate in Costa Rica by 50% between 1942 and 1954 to the installation of 10 455 privies.

Referring again to the California migratory labour camp studies (Table 1), Shigella infection rates in children of families having privies were approximately twice as great as the rates observed in families having an inside toilet. Similar comparisons of data reported in families in Georgia and in pre-school children in Kentucky indicated rates of five times and two times as high, respectively. The Guatemalan studies disclosed that the prevalence of Shigella was approximately three times greater among families living in areas where inside toilets were available in less than 50% of dwellings than among those where more than 50% of dwellings had such facilities.

In addition to recording the association of Shigella prevalence rates with various conditions of excreta disposal, the Kentucky studies reported that persons living in dwellings having privies experienced approximately twice as many cases of diarrhoeal disease as persons residing in houses with inside toilets. Ascaris infection rates were approximately four times higher among those persons using privies than among those using inside toilets.

It should be remembered in attempting to interpret the above data that considerations other than the availability of an inside toilet may have influenced the observed Shigella, Ascaris, and morbidity rates. Practically all houses with inside toilets have hand-washing and bathing facilities installed. Therefore, the increased availability of water for personal hygiene without doubt contributes to reductions in diarrhoeal disease and enteric infections.

At the same time, the need for sanitary disposal of excreta cannot be minimized in view of the obvious benefits derived from preventing faecal pollution of ground and surface water supplies, soil contamination and access of flies to faecal material. In addition, the presence of community sewage systems presupposes an increased availability of water for personal hygiene—a necessity for ultimate control of diarrhoeal disease.

Flies

Flies traditionally have been incriminated as vectors of diarrhoeal disease. The classic studies by Watt & Lindsay\(^1\) in Texas and subsequent studies by Lindsay et al.\(^m\) in Georgia demonstrated that significant reductions in diarrhoeal disease morbidity


\(^1\) Watt, L. & Lindsay, D. R. (1948) *Publ. Hlth Rep. (Wash.)*, 53, 1319

\(^m\) Lindsay, D. R., Stewart, J. H. & Watt, J. (1953) *Publ. Hlth Rep. (Wash.)*, 68, 361
and *Shigella* infections could be accomplished by fly control. Likewise, Weir et al., in comparing infant mortality rates in Egyptian villages between 1949 and 1950, concluded that the reduction in rate in 1950 could be attributed largely to control of fly-borne diseases.

In these three studies, fly control was accomplished with insecticides. During the latter phases of the Georgia studies, development of resistance by flies to the chlorinated hydrocarbon insecticides was accompanied by increased incidence of diarrhoeal disease. Similarly, development of resistance to insecticides in 1951 resulted in an increase to pre-control levels in both the fly populations and infant mortality rates in the Egyptian studies.

Since the use of insecticides alone to control flies is frequently over-emphasized, the significance of these studies and of subsequent world-wide reports of development of insecticide resistance is that attention is once again directed primarily to environmental sanitation for control of these vectors, with secondary reliance on insecticides. Prerequisites to permanent prevention of fly-borne diseases are: (1) prevention of access of flies to human faeces, (2) control of flies through elimination of environmental conditions favouring vector propagation, and (3) use of insecticides as adjuncts to environmental controls.

In connexion with excluding flies from human excreta, McCabe & Haines reported that installation of bored hole privies in a community in Georgia curtailed housefly breeding in privies but did not significantly reduce housefly populations in the community. The exclusion of flies from faecal material resulted in significant reductions in *Shigella* infections in children under ten years of age and in diarrhoeal disease morbidity rates. In economically advanced areas this problem can be met by development of community sewerage facilities and improved refuse sanitation. In under-developed areas the complexities of achieving sanitary disposal of excreta and preventing access of flies to faecal material generally are multiplied because of the mores of the people living in such areas.

**Weir report**

Comment on the Weir report on studies for improving rural health and sanitation in Egyptian villages is indicated because of misinterpretations that have been made of some of the conclusions contained in that report. Statistical data collected in five villages consisted of analysis of deaths, delineation of environmental deficiencies, and determination of communicable disease problems. Different sanitary facilities and public health services were provided in four villages, and the fifth was used as a control. The first 18 months of the project were directed to collection of base-line data, the second 18 months to inauguration of environmental controls, and the year 1951 to evaluation of the programme.

It is unfortunate that some of the conclusions reached—namely, that "the installation of sanitary water supply and latrines did not alter the infant mortality or crude death rates in any of the villages during 1951" and "it is not possible to indicate at the present time what possible reductions may have occurred in morbidity from endemic diseases and from enteric fevers as a result of water and latrine installation"—have been frequently referred to out of context and have therefore given rise to misinterpretation.

For example, the report adequately described sanitation conditions in the five villages and the rating of environmental sanitation. Of the arbitrary total of 106.5 points considered representative of adequate minimal requirements for sanitation, approximately one-half were related to minimum requirements for latrines, water supplies and bathing facilities. The average sanitary score of houses in the five villages ranged from 19.1 to 23.8 in the initial survey. Following environmental corrections, improvements in the sanitary score of houses in the four villages ranged from 29.2 to 43.3. These improved conditions were attributed "largely to the provision of water supply and latrines." While it is conceded that environmental improvements were accomplished, it is doubtful whether the provision of water sources (a hand-pumped well for every 200 persons) in most of which "bacterial counts exceeding 10 lactose fermenters per 10 cc of water were found periodically" and the installation of bored-hole latrines which "were used readily by the villagers when it was convenient for them to do so" represent adequate environmental controls to warrant condemnation of the importance of such facilities in the control of disease. In the report the authors carefully acknowledge that: "Interpretation of these [death] rates in terms of sanitary and preventive medical services within the various villages is extremely difficult in view of the wide
range of normal rates in the control village of Aghour El Kubra. If in two consecutive years the infant mortality rate can range from 273 to 175 as it did in Aghour El Kubra during 1950 and 1951, great caution must be exercised in interpreting the changes in these rates in the villages where basic sanitary services were initiated ".

It is not believed that the data in the Weir report provide sufficient justification for questioning the efficacy of environmental controls for prevention of communicable disease. Presumptive evidence to the contrary is overwhelming. In this connexion, it is of more than academic interest that Chandler 0 in 1952 made comparative studies of helminthic and protozoal infections in one of the "sanitized" villages and in the control village. Ascaris infections and hookworm infestations in the "unsanitized" village were much more prevalent than in the "sanitized" village, and the difference was attributed to a definite lowering of exposure in the latter.


Les maladies diarrhéiques transmissibles du nourrisson et de l’enfant

par le Dr R. BUTTIAUX, Chef de Service à l’Institut Pasteur de Lille, France

LES FACTEURS ÉTIOLOGIQUES PRINCIPAUX

Les maladies diarrhéiques contagieuses ou épidémiques peuvent être produites par des parasites, des bactéries, des toxines, et des virus.

Parasites intestinaux.


Quant aux helmintes, leur présence dans l’intestin de l’enfant entraîne souvent un syndrome diarrhéique. Parmi les nématodes, on rencontre des ascaris, oxyures, ankylostomes et anguillules. Dans les pays à climat tempéré, un fort pourcentage d’enfants, même élevés dans de bonnes conditions d’hygiène, sont porteurs d’Enterobius vermicularis (21,8% dans une enquête effectuée parmi des sujets de 2-6 ans); parmi les cestodes et les trématodes, on trouve Taenia saginata plus fréquent que Taenia solium, Hymenolepis nana, des bothriocéphales, Fasciola hepatica. Triozon (1958) a fait remarquer le nombre relativement élevé de distomatoses à grande douve dépistées dès qu’on fait appel à une méthode correcte de recherche des œufs dans les fèces.

Dans une enquête sur les maladies diarrhéiques, le dépistage des parasites intestinaux ne doit pas être négligé. Ils seront systématiquement recherchés dans les selles et dans un frottis des plis de l’anus (Graham, 1941).

Bactéries

La fréquence relative de certains groupes de bactéries intestinales selon l’âge du malade incite à les diviser en deux catégories: a) celles qui interviennent dans les diarrhées des enfants de tous âges; b) celles que l’on rencontre plus spécialement chez les sujets de moins d’un an.


Shigella. Les espèces en cause varient beaucoup selon la région. Sh. dysenteriae 1 reste fréquente dans les pays chauds où l’hygiène générale et les conditions de vie sont mauvaises. Elle est rare ou a disparu dans ceux où l’hygiène publique et individuelle est relativement satisfaisante. Sh. dysenteriae 2 n’est pas exceptionnelle; les maladies qu’elle provoque sont moins graves.

Il sera intéressant de préciser si les sérotypes du groupe de Large-Sachs ont un pouvoir épidémique. Il paraît douteux.

Les divers types de Sh. flexneri jouent un rôle important dans de multiples parties du monde et peuvent entrainer de vastes épidémies. Certains paraissent dominer dans des régions limitées; on constate en Belgique des syndromes dysentériiformes