Bull. Org. mond. Santé
Bull. Wld Hlth Org. } 1974, 51, 19-26

Field evaluation of environmental sanitation measures against cholera*

J. C. AZURIN[1] & M. ALVERO[2]

Data obtained in a controlled field study over 5 years in 4 communities showed that the provision of sanitary facilities for human waste disposal can reduce the incidence of cholera by as much as 68 %, while the provision of a safe water supply can decrease it by 73 %. Where both toilets and water supplies are provided, the incidence can be reduced by as much as 76 %. There was evidence that cholera infection gaining access to communities with these facilities tends to spread less and produce fewer secondary cases than in a community where such facilities are not provided.

Observations over the years have shown that a close relationship exists between poor environmental conditions and the incidence of cholera. Research has provided further evidence that cholera appears in communities in which sanitation conditions are below a certain level and sanitary facilities are deficient or lacking. Of these sanitary facilities, a potable water supply and a safe means of disposal of human wastes are the most important. Hence, any programme aimed at eliminating cholera from a community must of necessity include these two sanitary measures.

Communities implementing or desiring to implement these environmental sanitation measures may not be able to afford both measures simultaneously because of budgetary limitations. Priorities have to be considered. Although a substantial amount of work has been done, no precise determination has yet been made of the impact of these two sanitation measures on cholera. There was a need, therefore, for a field evaluation of their relative efficacy against the disease.

OBJECTIVES OF THE STUDY

The purpose of the study was to test the effect of either improved water supply or improved waste disposal (or both) against cholera infection. The study was carried out in Bacolod City, an area in which cholera is known to be endemic, in the central part of the Philippines. It started in mid-1968 and continued until the end of 1972. The objectives of the study were as follows:

(1) to compare the cholera incidence in a community where a safe water supply had been made available with the incidence in a similar community where there was no such facility;

(2) to determine the cholera incidence in a community where waste disposal facilities were provided;

(3) to compare the cholera incidence in a community where both safe water and waste disposal facilities were provided with the incidence in a control community; and

(4) to determine the effect of either safe water supply or waste disposal facilities or both in containing the spread of infection that has gained access to such communities.

It should be emphasized that the sanitary improvements tested were neither elaborate nor expensive but practicable—facilities that could be set up in cholera-endemic areas utilizing the community's resources alone or with minimal assistance from the government. This principle was adhered to because the results of this study, if favourable, were ultimately to be applied in the cholera eradication programme in the Philippines.

POPULATION AND AREA

This prospective study was carried out in areas within the jurisdiction of Bacolod City and involved

* From the Department of Health, Manila, Philippines.

[1] Director of Quarantine; Over-all Coordinator, Joint Philippines/Japan/WHO Cholera El Tor Research Project.

[2] Medical Specialist, Bureau of Health Services; Epidemiologist, Joint Philippines/Japan/WHO Cholera El Tor Research Project.

Table 1. Communities with different levels of sanitation, Bacolod City, 1968–70

Name of community	Category of sanitation	No. of households	No. of families	Total population
West Visayan	poor water, poor toilets	111	134	743
Dawis	improved water, poor toilets	125	135	803
Magsuñgay	poor water, improved toilets	108	128	787
Sibucao	improved water and toilets	118	135	756
	total	462	532	3 089

4 communities similar in size, geographic characteristics, and demographic composition. Other criteria considered in their selection were: (*a*) manageable size for surveillance and laboratory support; (*b*) accessibility; (*c*) history of confirmed cholera infection in the community in recent years; and (*d*) assurance of community cooperation.

Once the study communities had been chosen, appropriate sanitary improvements were undertaken by the staff of the Cholera Research Project under the supervision of a sanitary engineer, so that the 4 communities enjoyed different levels of sanitation as follows:

(1) a community with improved water supply and improved waste disposal;

(2) a community with improved water supply but poor waste disposal;

(3) a community with improved waste disposal but poor water supply; and

(4) a control community with poor water supply and poor waste disposal.

Table 2. Age distribution of population in 4 communities, Bacolod City, 1968–70

Age group (years)	West Visayan	Dawis	Magsuñgay	Sibucao	Total
0–5	142	131	109	145	527
5–9	118	129	146	128	521
10–14	92	109	103	96	400
15–24	118	146	168	122	554
25–44	187	189	158	187	721
45–64	63	77	87	60	287
⩾ 65	23	22	16	18	79
total	743	803	787	756	3 089

The characteristics of the 4 communities are given in Table 1, which shows that these communities were comparable as regards population size. The distribution of the population of the 4 communities by age group is shown in Table 2. There were no significant differences in the proportions of those under 15 and those over 15 years of age in the 4 communities.

CHARACTERISTICS OF THE STUDY COMMUNITIES AND THEIR SANITATION FACILITIES

All 4 communities are located along the sea coast, on the western edge of Bacolod City. Their inhabitants were fairly settled and were mostly fishermen or farmers or worked at various odd jobs in and around the city. The majority were "squatter" families belonging to the poorest socioeconomic classes. Many of the families in these close-knit communities were related in one way or another.

A brief description of each community, particularly its water and waste disposal facilities, is given below.

WEST VISAYAN (control). This community is located about 2 km north-west of the downtown area. It was composed of small thatched houses on a site delimited to the west by Guimaras Strait and to the south and east by the high concrete wall of an oil company's storage compound.

The water supply for the community came from 3 tube-wells provided with pitcher pumps. Most of the community drew water for drinking and domestic purposes from one centrally located tube-well. The water supply was never treated and no regular examinations were carried out to check its quality. There was no proper apron and the site was polluted; the pump was handled by the users in an insanitary way. In a sanitary survey, the water would no doubt be considered unsafe. The people defaecated wher-

ever it was convenient, as there were no toilet facilities.

DAWIS (improved water supply). This was part of a low-income neighbourhood in the mid-western section of the city not far from the downtown area. As in the other communities, the houses were closely packed, some were thatched, and several were dilapidated. There were houses built right down to the water's edge.

The water supply of this community came directly from the municipal waterworks system. Less than half of the residents had water-pipe connexions and bought metered water from the system.

The original sources of the municipal water system were 2 free-flowing mountain springs. Water was collected in 2 reservoirs high above the city. It was chlorinated and then distributed by gravity. Water pressure was further augmented with the aid of booster pumps in different parts of the city. Sanitary control of the quality of the water was carried out continuously by the waterworks office by means of regular bacteriological examinations and determination of residual chlorine at various points in the distribution system.

Being at a slightly lower level than the rest of the city, this study community enjoyed a plentiful supply throughout the day.

Facilities for the disposal of excreta were totally nonexistent; not a single house in this community had a toilet. The people used the beach, which, in this part of the city, was relatively dirty because of the considerable amount of refuse brought in by the tides.

MASUÑGAY (improved toilet facilities). This community, situated less than 2 km south-west of the downtown area, was part of a village set aside by the city government for displaced families. Squatters evicted from private or government sites elsewhere were settled there without charge.

The houses were built mostly of very light materials and had little space between them. Portions of the community were encompassed by the fringes of a shallow tidal basin and were under water during certain hours of the day.

Water was supplied by 4 wells provided with hand-operated pumps. Two of them were privately owned and 2 were built by the government for public use. From the latter, the whole of the community drew water for drinking and domestic purposes. No regular treatment or follow-up of any kind was carried out; the water potability was always questionable. Here too, the insanitary conditions at the tube-well sites and possible pollution from the spillwater and from the users must have detracted from the " safety " of the source.

For the purposes of the research project, communal toilets were built—1 toilet for about every 4 households, i.e., 1 toilet for every 25–30 residents. Before this, no toilets existed in the community.

Families related by consanguinity or affinity were grouped together and given one ready-made " water-seal " toilet of the squat type. These were made of concrete and constructed in such a way that a U-shaped water seal was maintained, just as in a standard water closet. One litre of water was enough to flush the toilet.

As the soil was sandy, steel drums were utilized for the pits. One end of the drum was opened before it was placed in an inverted position in a pit; the upper, unopened, end was level with the surrounding soil. The bottom of the pit was lined with gravel or small stones. On top of each steel drum was set a squatting plate on a thin concrete slab with the outlet passing through a hole in the end of the drum.

All construction materials were provided by the research project, while the community supplied the labour. Maintenance and cleaning of the toilets were left to the users. When the drums became full after about 1–2 years, the whole unit could be transferred to a fresh site.

SIBUCAO (improved water supply and improved toilet facilities). This community was situated on the edge of the city, about 4 km north-west of the city proper. It was well circumscribed, being surrounded by the sea and man-made fishponds that separated it from the rest of the district.

As in the other communities, the houses were made of light materials and were mostly thatched and built on stilts. The land belonged to big landowners in the city, to whom the community residents paid a token monthly rent.

Improvements in both water supply and excreta disposal facilities were carried out as part of this study. A piped water system was installed using a pre-existing, free-flowing artesian well. A 7.6-cm shaft was bored 53 m deep at the site. The water was lifted by a suction pump, driven by a 4.5-kw diesel motor that used diesel oil for fuel. A cylindrical storage tank with a capacity of 4 500 litres was installed 6 m above the ground to ensure adequate pressure at the different distribution points throughout the system.

There were 7 outlets in various parts of the community, in addition to those in the 3 buildings housing the public toilets. Each outlet was composed of a faucet from which the community drew water for drinking and other domestic uses. The outlets were located so that no house was more than 10 m away from any one of them.

It took the pump 1 h 15 min to fill the tank, and it operated continuously for 12 h each day. This provided the community with an average of 65–75 litres of water per person per day. The daily fuel consumption was 8 litres of diesel oil, the cost of which was borne partly by contributions from the residents and partly by subsidies from the city government.

Bacteriological examination of the water for coliform organisms was carried out at regular intervals. In addition to this water system, 3 pre-existing, hand-operated pump-wells were used for washing and bathing. The supply to this community can therefore be classified as adequate, accessible, and safe.

For excreta disposal, the community was provided with 3 toilet buildings, situated on the fringes of the community, that were constructed of strong materials. Each building housed 8 flush-type, glazed water-closets, complete with tanks and fittings, and was divided equally into 2 sections for males and females. Each section had a separate entrance and 4 toilets. Each building also had its own septic tank, 4.3 m long, 2.4 m wide, and 1.5 m deep, built of hollow blocks of reinforced concrete. The tank was divided into a digestion chamber and a leaching chamber, and the effluent was discharged untreated into nearby canals or creeks that drained into the sea.

One toilet was provided for every 28–30 inhabitants. Cleaning of the toilets was the responsibility of the households using them. Each day a specific household was assigned to clean the men's toilets and another the women's toilets.

To encourage the use of the toilets at night as well as by day, kerosene lanterns were installed in each unit.

All the construction materials, other than the 24 water-closets, were provided by the research project and the city government, as well as all the specialized labour for plumbing and carpentry. The water-closets were donated by a leading national manufacturer of sanitary installations. The community residents, in turn, supplied all the unskilled labour and some locally available materials.

During the period of construction of the sanitary facilities in the different communities, a health educator undertook a campaign to instruct the inhabitants in the proper use and maintenance of the facilities. No immunization or any other cholera control measure was carried out during the period of the study.

METHODS

To each of the 4 communities, an epidemiological aide—a midwife or person with equivalent training—was assigned to conduct surveillance. She worked under a nurse supervisor.

The aide visited the community daily and made a house-to-house canvass, taking a rectal swab from each patient found to have diarrhoea. The specimen was brought to the project laboratory on the same day and examined for cholera vibrios. If the diarrhoea was severe, repeat swabs were taken again the next day; no further swabbings were made unless the case was bacteriologically confirmed as cholera.

For the purposes of this study, a " cholera case " was one with gastrointestinal symptoms and a rectal swab positive for cholera vibrios, even if the symptoms were not severe enough to require treatment.

Once a diarrhoeal case was confirmed as cholera, surveillance was intensified by swabbing all members of the household and close social contacts of the case. Depending upon circumstances, the water was sometimes sampled in the cluster of houses surrounding the index household.

RESULTS

The evaluation indicator for this study was the number of bacteriologically confirmed cholera infections.

At first, the incidence of diarrhoeal episodes, irrespective of etiology, was considered as a possible indicator, especially if cholera should fail to attack the communities. This idea had to be abandoned, however, because of the distortions engendered in evaluation by the many factors that caused diarrhoeal disease, for which the laboratory was not equipped to make definitive diagnoses.

After 4½ years of surveillance (from 1 June 1968 to 31 December 1972), the number of cholera-infected individuals detected in the 4 communities was as shown in Table 3. These data show that improvement of either water supply or toilet facilities or both was effective in significantly reducing the incidence of cholera in the corresponding study

Table 3. Relation between sanitation and cholera in Bacolod City, 1968–72

Community	Sanitation category	1968	1969	1970	1971	1972	Total
		No. of bacteriologically confirmed cholera infections					
West Visayan	control	31	44	64	14	18	171
Dawis	water (W)	10	19	9	5	7	50
Magsuñgay	toilets (T)	13	17	10	10	8	58
Sibucao	T + W	17	5	12	7	0	41
total		71	85	95	36	33	320
		Incidence rates per 1000 population					
West Visayan	control	41.7	59.2	86.1	18.8	24.2	230.2
Dawis	water (W)	12.4	23.7	11.2	6.2	8.7	62.3
Magsuñgay	toilets (T)	16.5	21.6	12.7	12.7	10.2	73.7
Sibucao	T + W	22.5	6.6	15.9	9.3	0	54.2
		Effectiveness of sanitation measures (%)					
West Visayan	control	—	—	—	—	—	—
Dawis	water (W)	70.2	60.0	87.0	66.9	64.0	72.9
Magsuñgay	toilets (T)	60.4	63.5	85.2	32.5	58.0	68.0
Sibucao	T + W	46.1	88.8	81.6	50.5	100.0	76.4

communities as compared with the control. However, as between the 3 kinds of sanitary improvements, the differences in incidence were relatively minor. It may, however, be noted that no cases were detected in 1972 in the community (Sibucao) where both toilet and water facilities had been provided.

The age distribution of the confirmed infections in the communities with different levels of sanitation during the 5-year duration of the study is shown in Table 4. The disease incidence was highest among the very young and lowest among the adults in all the communities; thus it is unlikely that the older age groups (⩾15 years) contracted extraneous infections while they were out at work during the day. The rates were lower in the community in which

Table 4. Number of cholera cases and age-related incidence in 4 communities, Bacolod City, over 5 years (1968–72)

Community	Sanitation category	Age group (years)											
		0–4			5–14			⩾15			Total		
		No. of cases	Population	Rate/1000	No. of cases	Population	Rate/1000	No. of cases	Population	Rate/1000	No. of cases	Population	Rate/1000
West Visayan	control	77	142	542.2	75	210	357.1	19	391	48.6	171	743	230.1
Dawis	water (W)	28	131	213.7	14	238	58.8	8	434	18.4	50	803	62.3
Magsuñgay	toilets (T)	35	109	321.1	13	249	52.2	10	429	23.3	58	787	73.7
Sibucao	T + W	28	145	193.1	9	224	40.2	4	387	10.3	41	756	54.2

Table 5. Frequency of introduction of cholera infection into 4 communities, Bacolod City, 1968–72

Community	No. of times infection was introduced	No. of introductions that spread	Proportion of introductions that spread (%)	No. of cases involved in spread	Average no. of cases per spread
West Visayan	31	22	71	162	7.4
Dawis	24	12	50	38	3.2
Magsuñgay	26	13	50	45	3.5
Sibucao	17	9	53	33	3.7

both water supply and toilets were improved than in the communities in which either water or toilets were provided. The percentage effectiveness of the sanitary measures in reducing disease incidence was also highest in the community in which both water supply and toilets were improved.

It is interesting to observe the behaviour of infection that gained access to the study communities during the period of observation. The distribution of the cases by day of occurrence reveals some clustering of cases by time. When correlated with epidemiological investigation in the field, an idea of the frequency of introduction of infection or the number of times it gains access to the community can be obtained. The results are shown in Table 5.

From these data, it seems that when cholera gains access to a community, secondary spread is less likely where sanitation conditions are good, and, if it does spread, the number of cases involved is considerably smaller in the communities with improved sanitation. The practical significance of such findings is obvious. This is true even when extrapolations are made to standardize the number of introductions of infection.

Table 6. Reduction of cholera incidence in 4 communities, Bacolod City, 1971–72

Community	No. of cases	Rate/100	Reduction in incidence (%)
West Visayan	32	4.31	—
Dawis	12	1.49	65.4
Magsuñgay	18	2.29	46.9
Sibucao	7	0.93	78.4

Another interesting observation that was made in the communities with improved sanitation, especially in Sibucao, where both water and toilets were improved, was the noticeable improvement in the cleanliness of the residents and of their homes as the study progressed. This probably helped in further reducing the incidence of cholera during the last 2 years of the study in 1971–72. Table 6 shows the incidence for those years.

The results for 1971 and 1972 are quite striking. The community with improved water and toilet facilities (Sibucao) shows a considerably greater reduction in incidence than the community where only the toilets were improved. This difference might be due to the fact that during the first 1 or 2 years of the study the facilities were not used so assiduously as in later years. During the first 2 years, some people did not use the sanitary facilities at all. The results were therefore not striking. However, when the population began to depend on the facilities provided and to use them regularly, the effects became more apparent. The percentage reduction of cholera incidence during the last 2 years of the study in the community where toilets were provided was 46.9%, whereas in the community for which both toilets and water supplies were provided there was a reduction of 78.4%.

CONCLUSIONS

The data collected in this controlled field study carried out over a period of 4½ years show that the provision of sanitary facilities for human waste disposal can reduce the incidence of cholera by as much as 68%, while the provision of a safe water supply can reduce it by 73%. Where both toilets and water supplies are provided, the incidence can

be reduced by as much as 76%. Evidence points to the fact that cholera infection is less likely to spread and produce secondary cases in a community where sanitary facilities are provided than in a community without such facilities.

In the analysis of the results of the last 2 years of the study, there is a considerable difference in the incidence rates between the community where water-seal latrines and good water supplies were both provided (Sibucao) and the community where latrines alone were provided (Magsuñgay).

The findings of this study offer factual support for the effectiveness of environmental sanitation measures against cholera. Moreover, they demonstrate that relatively simple and inexpensive measures are sufficient for the control of cholera, which is in agreement with the fact that cholera has disappeared from many areas with such limited facilities whereas shigelloses and salmonelloses are still frequent.

However, some of the credit for the success in the Philippines should also go to the population, whose collaboration and gradual acceptance of the new sanitation facilities and of the need for more hygienic habits led to a general improvement in environmental conditions. The study period was a time of considerable improvements in education and hygiene, largely through the efforts of the population itself, and therefore the achievements should be viewed as the product of community participation.

A study of the effectiveness of indoor piped water in a community with privies in the USA has shown that there were 50% fewer infections with *Shigella* among those who had water inside the house than among those with water outside (1). People with water outside the premises had one-third more diarrhoeal infections than people with water available on the premises. Other studies have shown that piped water and facilities for the disposal of excreta are of greater importance than fly control in the prevention of diarrhoeal disease, and there seems to be a good correlation between the provision of abundant pure water and a reduction in the incidence of diarrhoeal diseases (2). The effect of the improvement of sanitation in rural areas is most noticeable in children under one year of age. Children living in a sanitary environment tend to contract diarrhoeal disease less frequently than children with the same economic and social background living in poor sanitary conditions (3).

While it is evident that sanitation plays a significant role in the control of diarrhoeal diseases, it seems that relatively small improvements are far more beneficial in the control of cholera than in the combat of shigelloses and other diarrhoeal diseases and therefore constitute an effective and inexpensive interim measure for cholera control in rural areas.

RÉSUMÉ

ÉVALUATION SUR LE TERRAIN DE MESURES D'ASSAINISSEMENT DU MILIEU CONTRE LE CHOLÉRA

Une étude contrôlée, couvrant une période de 5 ans, a été entreprise aux Philippines en raison d'observations indiquant un rapport étroit entre les conditions environnementales et l'incidence du choléra. On sait par ailleurs que le choléra se propage dans des collectivités où le niveau d'hygiène est inférieur à la normale.

L'étude, qui a débuté en 1968, se proposait de déterminer l'incidence du choléra *a*) dans une collectivité où l'approvisionnement en eau avait fait l'objet d'améliorations; *b*) dans une collectivité où des installations pour l'évacuation des excreta avaient été construites; *c*) dans une collectivité bénéficiant de ces deux types de mesures. Une collectivité témoin a été considérée. Les améliorations apportées au niveau d'hygiène n'étaient ni compliquées ni coûteuses, et on s'est surtout soucié de leur aspect pratique.

On constate que la fourniture de commodités pour l'évacuation des déchets d'origine humaine peut diminuer l'incidence du choléra dans la proportion de 68%. La mise à la disposition de la population d'une eau de bonne qualité peut la réduire de 73%. Si les deux mesures sont mises en œuvre conjointement, la baisse de l'incidence peut atteindre 76%. L'infection cholérique, lorsqu'elle atteint de telles collectivités, a moins tendance à s'étendre et elle produit moins de cas secondaires que dans une collectivité démunie de ces moyens. L'analyse des résultats des deux dernières années de l'étude fait ressortir une différence statistiquement significative des taux d'incidence cholérique entre la collectivité pourvue de latrines et approvisionnée en eau et la collectivité où seule l'installation de latrines a été réalisée.

Cette étude montre l'efficacité de mesures d'assainissement relativement simples et peu onéreuses dans la lutte contre le choléra.

REFERENCES

1. SCHLIESSMANN, D. J. ET AL. Relation of environmental factors to the occurrence of enteric diseases in areas of Eastern Kentucky, Washington, D.C., US Dept. of Health, Education, and Welfare, 1958 (*Public Health Monograph* No. 54).
2. WOLFF, H. L. ET AL. *Bull. Wld Hlth Org.*, **41**: 952-959 (1969).
3. RUBENSTEIN, A. ET AL. *Publ. Hlth Rep. (Wash.)*, **84**: 1093-1097 (1969).