PANAMERICAN HEALTH ORGANIZATION

WORLD HEALTH ORGANIZATION

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CONTROL OF THE BACTERIOLOGICAL QUALITY OF DRINKING WATER

The Executive Committee, at its 72nd Meeting in July 1974, expressed concern over the bacteriological quality of drinking water and adopted the following Resolution VII proposed by the Representatives of Canada, Cuba, and Mexico:

THE EXECUTIVE COMMITTEE,

Considering that the Member Governments have expressed concern about the epidemic outbreaks of enteric diseases and that these diseases affect the infant and young populations in particular;

Recognizing that non-potable water represents an important vehicle for the transmission of some of the diseases mentioned; and

Taking into account the great efforts being made by the countries to provide adequate supplies of drinking water to the urban and rural populations,

RESOLVES:

To propose to the XIX Pan American Sanitary Conference that it consider the approval of a resolution:

1. Urging the Ministers of Health and other responsible authorities to give greater attention within the framework of the water supply programs to bacterial qualities, together with the preparation of quality standards, the improvement of

existing laboratories or the establishment of new laboratories, the training of personnel, and the adoption of the machinery required for exercising effective quality control.

2. Requesting the Pan American Health Organization to give greater attention to the promotion of activities leading to water quality control and to provide advisory training and other services at the request of the Governments for establishing and carrying out effective programs for the control of the bacterial quality of water.

The Problem

Although great progress has been made in providing water to an increasing number of people in the Americas, a large and challenging task still remains to be done to insure that such supplies are of satisfactory quality.

The need to consider water quality along with quantity is evidenced by the morbidity and mortality statistics which indicate that the incidence of water-borne diseases in the Americas is alarmingly high. Data to support this is included in Annex I.

From the data alone it is not clear just how water supplies may be implicated in these outbreaks. For example, the El Salvador epidemiological investigation report[1] indicates ". . . interrelated factors have probably contributed to the re-emergence of epidemic dysentery in Central America. . . . First the organism itself has changed, as reflected by the fact that pre-epidemic strains were sensitive to tetracycline and chloramphenicol while those causing the epidemic were resistant to these antibiotics. Second, a susceptible previously unexposed human population had grown tremendously. And third, the mobility of this population over recently constructed roads contributed to rapid spread of the disease. These factors, taken together, probably explain why the epidemic occurred and why it was so severe. . . ."

No direct mention is made to water as a major factor in the pandemic. Reference is made to increased resistance of the organism to antibiotics, but none to the change in resistance of the organism to chlorine.

In Mexico, the 1972 typhoid fever outbreak was reported to be due to a chloramphenicol-resistant strain of Salmonella typhi. This epidemic was accompanied by prolonged use of antibiotics which apparently did little to reduce the number of typhoid carriers.

There is ample evidence, however, from an examination of recorded history of water-borne diseases that contaminated water supplies are a contributing factor.

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[1]Vol. VII, No. 4, PASB Boletín. 1973.

The problems associated with the control of the bacteriological quality of drinking water may extend from the quality of the raw water to be treated to poor handling practices by the consumer. Basically, the major deficiencies can be listed as follows:

1. Poor quality of raw water

2. Intermittent operation of systems--both advertent and inadvertent

3. Hazardous plumbing arrangements, roof tanks, high suction pumps for building supplies, cross-connections with fire and unsafe supplies, etc.

4. Long and well recognized but still not well attended problems of operation and maintenance, including:

   - Unreliable chlorination
   - Filter breakthroughs
   - Leaky mains and laterals
   - Inadequate operation and maintenance schedules,

   and

5. Lack of an effective water quality control system.

Water Quality Control

The Water System

In protecting the quality of a water supply it is necessary to give careful consideration to all of the component parts of the system because quality can be affected at each of many points. For example, raw water sources should be protected from gross contamination so that severe strains will not be placed on treatment plants. Failure in this first step may mean that all succeeding steps may be much more difficult. Concentration on a high level of treatment and/or development of a safe water supply source is of little value if the distribution system permits contamination through excessive leakage and cross-connections. Since many systems in Latin America operate under low pressure, often with a need for storage tanks, possibilities for cross-connections are obvious.

There is evidence also that for various reasons disinfection of water supplies is intermittent. Disinfection is an essential safeguard to water quality because a strong correlation exists between residual chlorine in a system and acceptable bacteriological quality.

Program Content

In view of these factors, an effective water quality control program should include the following:

(a) Adequate legislation
(b) Institutional development
(c) Standards, codes, and enforcement procedures
(d) Monitoring and surveillance, and
(e) Sanitary surveys.

The implementation of a water quality control program does not need to be delayed until specific legislation is developed, assuming that existing health legislation probably covers the basic requirements of the water quality control program. This legislation should include statutes which define the scope of authority, the agency which will administer the law, and the right of the agency to establish the regulations covering the production and protection of safe drinking water. There should also be provision for compliance and attendant penalties for non-compliance.

The agency in charge of surveillance must be provided with quality standards for drinking water. The World Health Organization International Standards for Drinking Water have been adopted by a number of countries and others have established their own based on modification of the WHO standards (see Annex II).

The development of bacteriological water quality standards is not without difficulty. Among the elements to be resolved are what bacteriological standards to use. If they are different from those in the International Standards for Drinking Water, how different can they be? How much contamination, in terms of coliform content, is acceptable and at what risk? This is a difficult epidemiological problem.

Assuming that agreement can be reached on quality standards, decisions need to be made on the pattern of sampling; the analytical methods to be used; responsibility for operating the quality control system; and how compliance with the standards will be enforced.

Consideration should also be given to the development of water quality indices, from the standpoint of health and economics. Protection of health and investment in water supply systems are of extreme importance.

The concept of water quality indices is associated with the need for, and the ability to, communicate about water quality in a language that is both understandable and consistent.

In the United States of America, a water quality index has been developed based upon an equation capable of interpreting the combined effect of nine water quality factors into a single numerical expression.

The responsible agency should also work with other government organizations in the preparation of those codes and standards required to promote safe water supplies. These would include plumbing codes and manufacturing standards.

Surveillance of drinking water quality includes the continuous and in-depth review and assessment of the level of safety of the drinking water facilities. This includes regular examination of the quality and quantity of source, the adequacy of treatment, the level and consistency of pressure in the distribution system, quality monitoring, cross-connection control, residual levels of chlorine in system, construction and repair methods, and effectiveness of operation.

Also included in surveillance is the need to reduce or eliminate environmental hazards in the systems and to institute improvements wherever necessary. Equally important to the concept of surveillance are other general activities connected with the water supplies, including training programs of operational and maintenance personnel, public information campaigns for safe water and the prevention of water-borne diseases, and health education.

From the point of view of water quality control, it is desirable to examine water quality in terms of specific constituents in the water provided. In order to determine if the water supplied is safe for human consumption, samples should be taken from the water system and analyzed.

The frequency of sampling, the number of samples taken, and the level of analysis to be performed depend on local situations. Such conditions (such as local standards) will, of course, dictate what is appropriate and attainable by the designated agency in a given country.

The development of a water quality control program depends upon the level of development of a country. It is not useful to attempt to impose overly sophisticated programs in countries in which the existing infrastructure and expertise will not be able to support such programs. For this reason, it is more realistic to develop the program to meet the existing situation in the country, and then to subsequently develop the program by stages to higher levels. The WHO document, Surveillance of Drinking Water Quality, A Guide for Development of Nationwide Programs in Developing Countries, includes specimen programs for four increasingly sophisticated levels of development which are attached as Annex III.

Rural Water Supplies

Water supply systems in small villages and in rural areas present special problems in water quality surveillance and control, due to the number of such "systems," their dispersed nature, lack of qualified operators, and lack of funds. Obviously, contamination can and does occur. Generally, this contamination can be traced to the source of supply and to construction deficiencies. It is possible to develop quality control programs covering these aspects of water supply. They would include training of local personnel as operators, source approval, sanitary surveys, and bacteriological testing.

Special attention should be given to the slum area problem. The water contamination situation is greatly complicated by the high population density, few house connections, intermittent service, leakage, and the absence of an adequate sewage disposal system. These slum areas, of course, provide fertile conditions for the spread of water-borne epidemics, especially when safe, piped water is not available. The slum-dwellers then resort to contaminated surface or groundwater supplies, to private sellers of water, or to illegal tapping of municipal mains--thereby introducing contamination into the piped water supply. While this slum area problem should have the highest priority for the installation of new systems, this does not always occur. These areas should, therefore, receive the highest priority for water quality control.

Conclusions

As governments contemplate multibillion dollar expenditures for water supply development in the decade of the seventies, quality must become an equal partner with quantity. It is essential to reassess water supply programs to determine weak points in the system which may create water quality problems. Particular attention must be given to surveillance and monitoring, leakage control, and effective maintenance and operation, including disinfection. Assistance should be sought in deciding the level of a water quality program best suited to a country. One source of reference is the WHO document, Surveillance of Drinking Water Quality, A Guide for Development of Nationwide Programs in Developing Countries.

The success of any program will depend also on the availability of trained manpower and laboratory facilities for bacteriological analysis. Both should be given special attention.

The Pan American Health Organization can assist the countries' efforts through some of its ongoing and planned programs. Among these are the following:

1. Through CEPIS:

   (a) Coordinate a program of analytical quality control in the Region.

   (b) Prepare a Manual on Internal Quality Control for Laboratories of the Region.

   (c) Assist in developing water quality indices.

   (d) Continue to provide technical services on water resources management.

(e) Continue to assist in improving and expanding present water treatment plants. A manual on methods and processes for evaluation of water treatment processes has been completed--"Theory, Design, and Control of Water Clarification Processes."

(f) Conduct investigations into the advisability of substituting the determination of free and combined chlorine residuals for total coliform counts in certain circumstances.

(g) Assist in improving communications between laboratories in the Region.

(h) Assist in distributing information on analytical methodology and instrumentation, and in providing samples for intralaboratory and interlaboratory quality control.

2. Increase training programs in water quality related subjects giving particular attention to those problems which have not been the subject of any previously held training courses.

3. Encourage increases in production of chlorine where known sources exist in the Region and disseminate information on available supplies.

4. Assist in providing effective maintenance and operation of facilities for water supply systems. This could include assisting governments in the preparation of study project proposals in which maintenance and operation and the monitoring of water quality are prime objectives (two such project proposals to UNDP are under preparation for Member Countries).

5. It is expected that with the development of the Pan American Center for Human Ecology and Health it will be possible to initiate in-depth epidemiological investigations which will provide the information needed to take more intelligent action in controlling the bacteriological quality of water.

6. In mid-1975, hold a Water Quality Control Conference in which government representatives and representatives of the international agencies will meet to study water quality control problems in the Region and propose approaches to be taken by governments with PAHO assistance.

Annexes

OUTBREAKS OF TYPHOID FEVER, BACILLARY DYSENTERY, AND ENTERITIS IN THE AMERICAS

The data depicted in the graphs that follow are divided into three groupings:

Northern America - Includes essentially Canada and the United States of America

Middle America - Includes Central America, Mexico, and the Caribbean

South America - Includes the countries of the South American Continent

The data show only cases or deaths, not rates. Since population increases have been large during the periods reported, cases tell only part of the story. The following is a further explanation of the situation.

1. Typhoid Fever: Cases, 1963-1972

The number of cases has remained somewhat the same during this recent ten-year period, with an upturn in 1971-1972 for Middle America, reflecting probably the epidemic in Mexico. A similar upturn in South America reflects scattered increases in incidence. Comparing the three groupings, the case rate has remained almost constant for Northern America, paralleling the very low caseload. For Middle America, the case rate declined rather steadily, from about 16 cases per 100,000 in 1963-1964 to about 8 in 1971, but jumped to almost 13 in 1972, again probably reflecting the outbreak in Mexico. For South America, the case rate increased from 22 to 35 in the first four years and dropped to a steady 15-plus in the last three years. In the year 1972, there were still 41,441 cases of typhoid fever reported in Middle and South America.

2. Typhoid Fever: Deaths, 1963-1972

The largest number of deaths continues to occur in Middle America, although the death rate has dropped in the ten-year period by about one-third, from around six per 100,000 to around four. The number of deaths in South America has dropped by about two-thirds in the ten-year period--even in the face of large population increases--and the death rate has dropped in about the same proportion, namely, from three to around one per 100,000.

3. Bacillary Dysentery: Cases, 1963-1971

The statistical classification, "bacillary dysentery," includes the several types--Shiga, Flexner, Sonnei, and so on. Clearly indicated in the

graph is the outbreak that occurred in Middle America in 1969-1972. "Outbreak" is indicated because the peak number of cases shown in the graph is 50,000 in 1971 for all of Middle America. These are cases that were reported in the official vital statistics systems of the countries.

The number of cases that occurred in El Salvador alone in 1969-1972, according to an epidemiological study published in Vol. VII, No. 4, of the PASB Boletín, was 197,000. The corresponding number of deaths was 11,750. These cases and deaths are so called "registered" ones. According to the Health Statistics Department of PASB, this means that they are registered in hospitals, clinics, and other local places, but are not necessarily officially reported to the national vital statistics agency. This is a problem that is receiving attention in the countries. It illustrates the difficulty in assessing accurately the effects of environmental and other health measures to reduce disease.

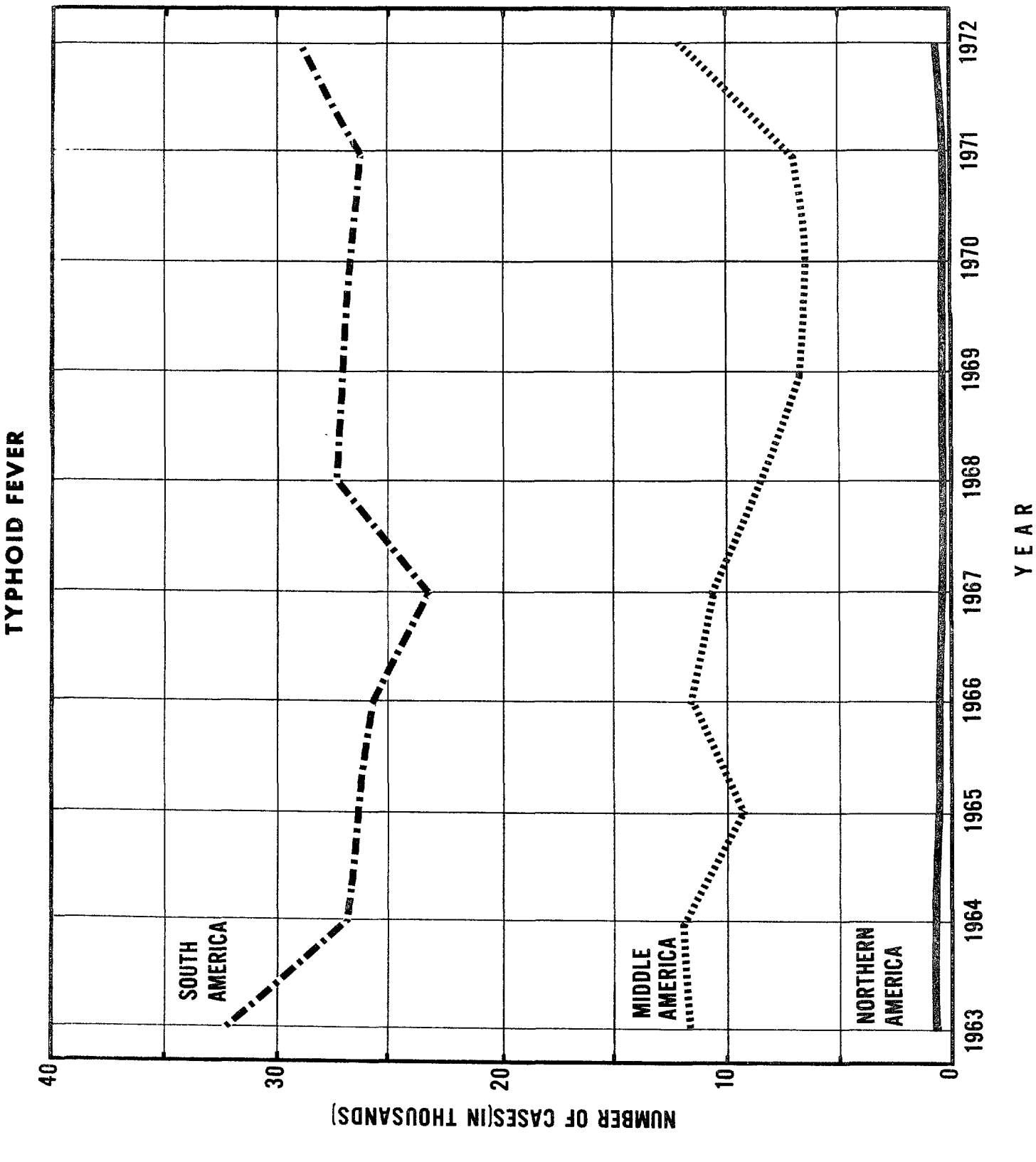
Another interesting aspect of the graph is the large increase in cases in South America. This increase is accounted for almost entirely by Argentina, where the reported cases jumped from 1,543 in 1970 to 77,952 in 1971 and 88,615 in 1972. No explanation of this change is offered.

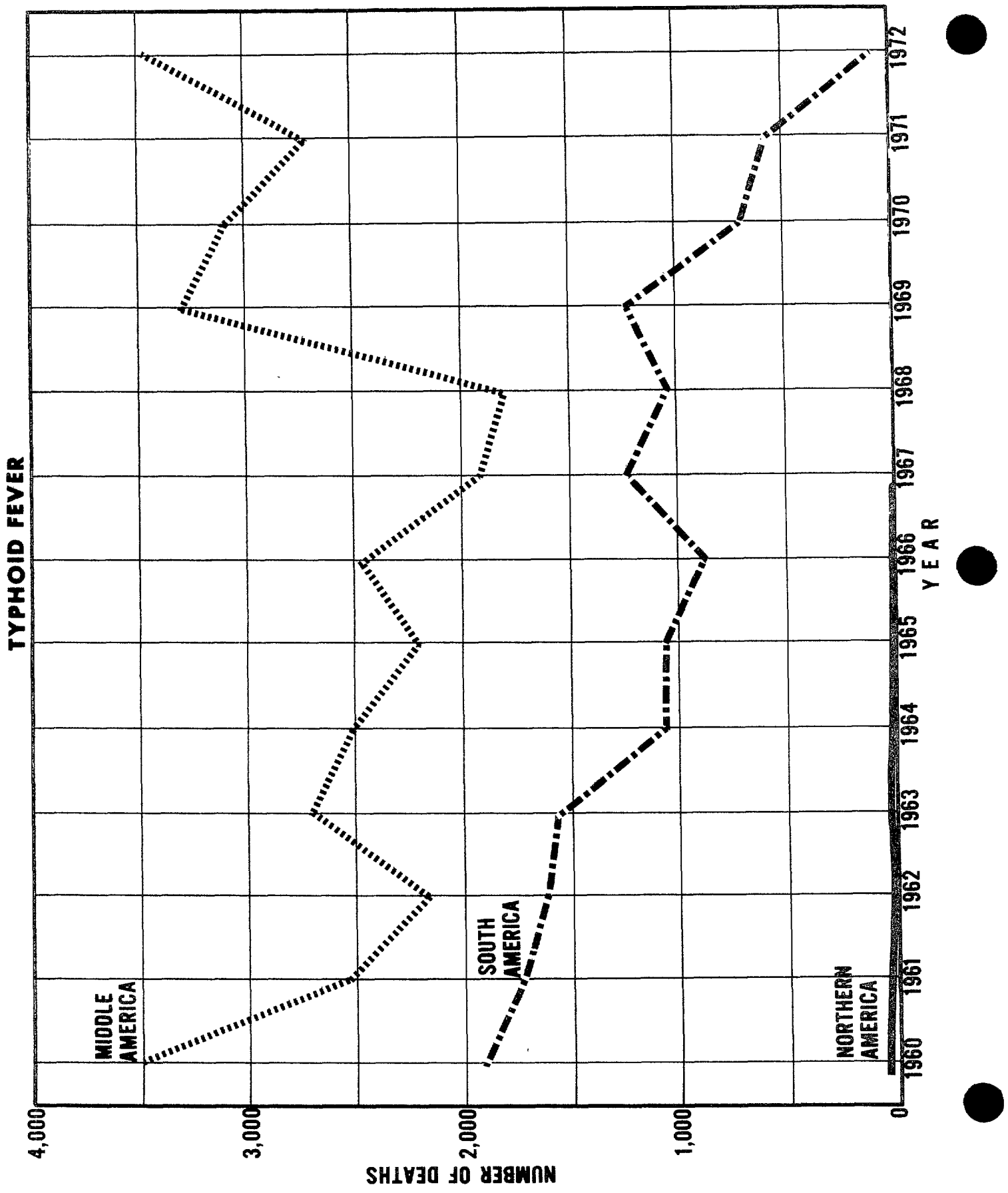
Case rates for Middle and South America reflect the large increase in cases in the 1969-1972 period. Otherwise, except for the 1968-1969 rise in South America, there had been a rather steady decline in rates amounting to a 30 or 40 per cent reduction over the first 6-7 years of the 10-year period.

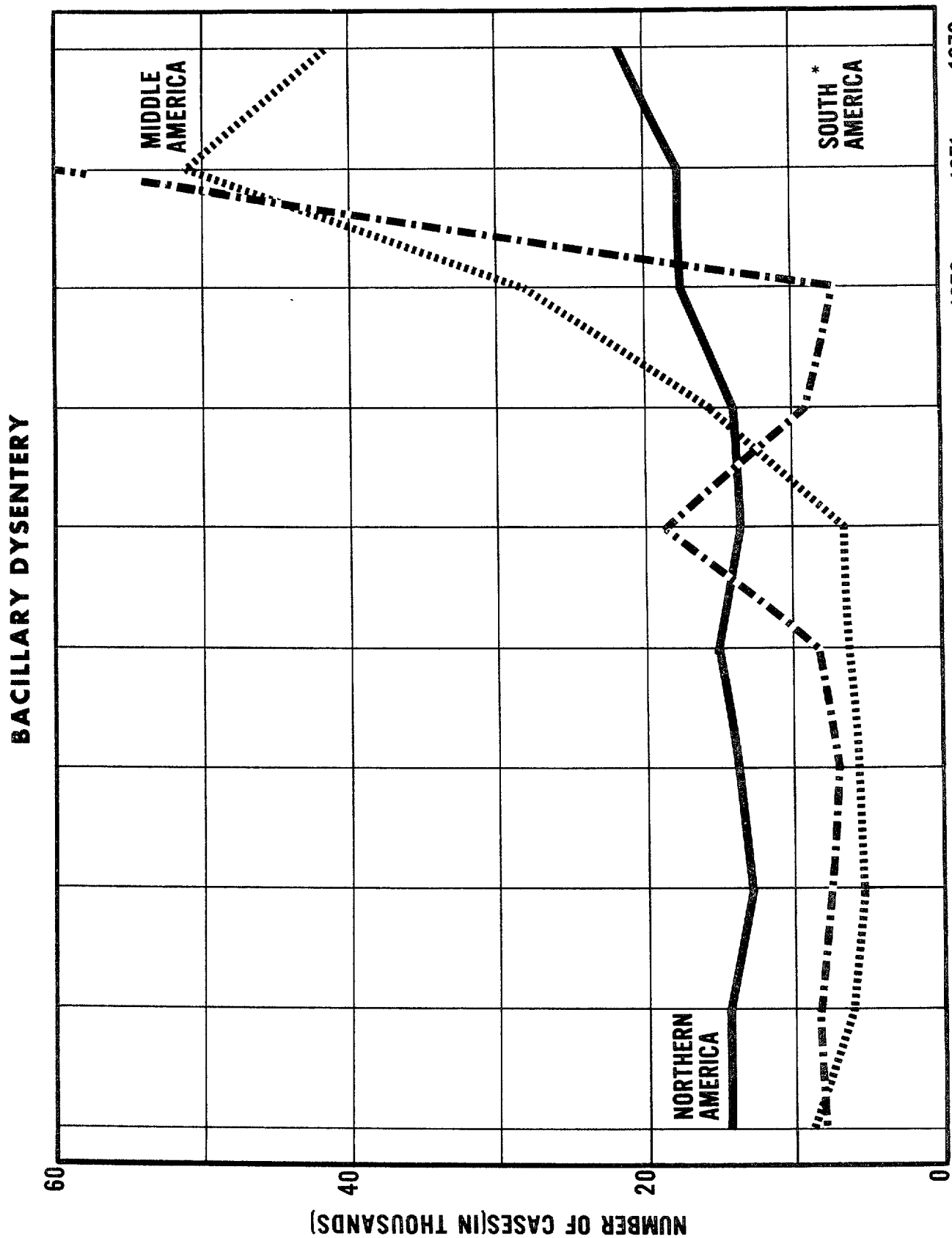
Of interest also is the recent rise in both cases and rates in Northern America after several years of little change.

4. Enteritis: Deaths and Rates, 1959-1972

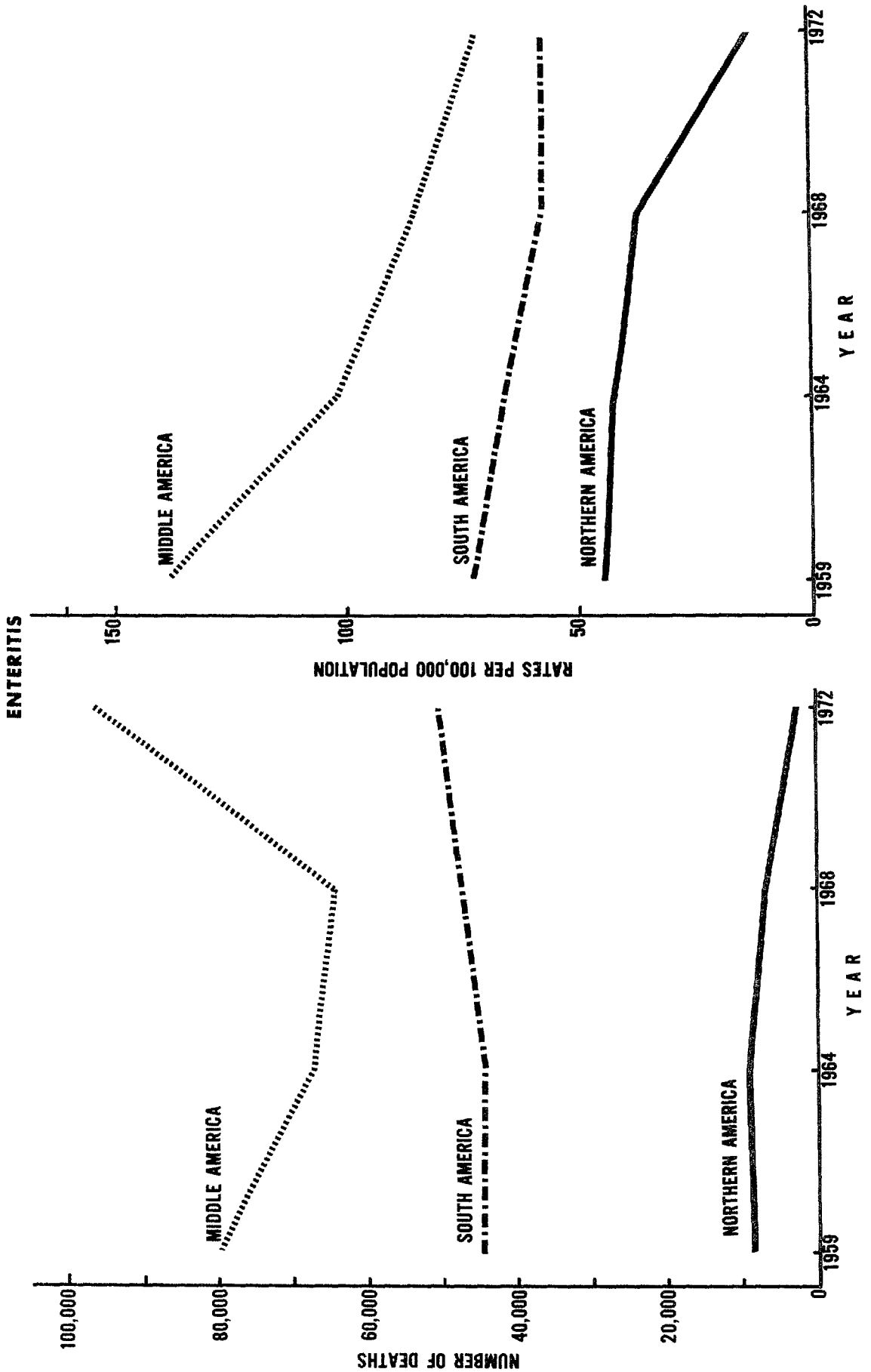
The statistical classification "enteritis," as used in these graphs, includes unspecified diarrheal diseases and dysenteries, gastroenteritis, and colitis. The classification also includes multiple causes where the terminal condition was diarrheal. Examples are malnutrition, whooping cough, or measles--with diarrhea as the terminal cause. Although the number of deaths and the rates are highest in Middle America, there has, however, been a steady decline in rates. The rates have likewise declined steadily in South America.


TYPHOID FEVER
NUMBER OF CASES(IN THOUSANDS)
40
30
20
10
0
1963
1964
1965
1966
1967
1968
1969
1970
1971
1972
YEAR
SOUTH AMERICA
MIDDLE AMERICA
NORTHERN AMERICA


TYPHOID FEVER
NUMBER OF DEATHS
4,000
3,000
2,000
1,000
0
1960
1961
1962
1963
1964
1965
1966
1967
1968
1969
1970
1971
1972
YEAR
MIDDLE AMERICA
SOUTH AMERICA
NORTHERN AMERICA



*Reported cases from South America were 84,120 in 1971 and 94,044 in 1972


ENTERITIS
RATES PER 100,000 POPULATION
150
100
50
0
MIDDLE AMERICA
SOUTH AMERICA
NORTHERN AMERICA
1959
1964
1968
1972
YEAR
NUMBER OF DEATHS
100,000
80,000
60,000
40,000
20,000
0
MIDDLE AMERICA
SOUTH AMERICA
NORTHERN AMERICA
1959
1964
1968
1972
YEAR

DRINKING WATER QUALITY SURVEILLANCE

(Taken from Table 14 - World Health Statistics Report - Vol. 26, No. 11, 1973)

AMERICAS
(Latin America and Caribbean)

Agency Responsible

Public Health Authority	13 countries
With another agency	7 countries

Water Quality Standards, Adopted

WHO Standards	
Adopted to suit country needs	7 countries
Adopted in toto	
National standards prepared before	3 countries
Other Standards	1 country

Water Quality Standard, Not Adopted

Not contemplated	2 countries
Contemplated in the near future	3 countries
In preparation	1 country

Extent and Frequency of Bacteriological Examination

	No. of Countries	
Examination	Urban	Rural
Every supply, regularly	8	2
Some supplies, regularly	13	6
Every supply, occasionally	2	0
Some supplies, occasionally	10	15
No examination	0	6

SPECIMEN SURVEILLANCE PROGRAMS*

LEVEL I

SURVEILLANCE OF DRINKING WATER QUALITY

Description

This is an initial program proposed for adoption in those countries that presently have no formal program and severely limited economic development.

Law and Regulation

Basic legal authority creating or designating the surveillance agency and empowering it to carry out the duties below.

Drinking Water Standards

Adoption of bacteriological standards in urban systems.

Standard Methods of Analyses

As needed for above plus residual chlorine.

Laboratory

Develop a central laboratory, possibly as part of the national health ministry laboratory.

Sanitary Surveys

Program for capital and major cities.

Approval of Source

Program for capital and major cities.

Reporting Requirements

Water works in major cities required to submit one sample per month for analysis.

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*From WHO Document, Surveillance of Drinking Water Quality, A Guide for Development of Nationwide Programs in Developing Countries

Design Standards

Informal technical assistance.

Regulation of Special Water Supplies

Government hospitals, major air, rail, and ship terminals.

Training

On job training for surveillance staff, participate in international training programs if and when available, use short-term consultants.

Technical Assistance

On request but no full-time staff on this task.

Design Standards

Formal program for preconstruction approval of new works for largest systems, published guidelines.

Plumbing Code

Codified and enforced in major cities and for major manufacturers of plumbing fixtures.

Training

Strong programs of short courses, support of institutional training and educational programs, and operation of its own technical institute if necessary.

Technical Assistance

Active program with full-time staff.

Regulation of Special Supplies

All supplies serving significant population numbers. Regulation of bottled water and ice.

Other

Cross-connection control program, formal participation in health education program of health ministry.

SPECIMEN SURVEILLANCE PROGRAMS

LEVEL II

SURVEILLANCE OF DRINKING WATER QUALITY

Description

This is a basic program for formal adoption in those countries that presently have nominal or superficial programs with severe limitations on scope and effectiveness.

Law and Regulation

Basic legal authority authorizing the program and powers sufficient to carry out program below, including development of agency regulations.

Drinking Water Standards

Adoption of bacteriological standards in urban areas.

Standard Methods of Analysis

As needed for above plus residual chlorine.

Laboratory

Establishment of a central water supply laboratory.

Sanitary Surveys

Required for all city water supplies; emphasis on source and treatment.

Reporting Requirements

All cities required to send in monthly samples. Major cities to report their own bacteriological tests. All supplies to monitor and report chlorine dosage and residuals.

Design Standards

Informal technical assistance.

Regulation of Special Supplies

Government hospitals, major transportation terminals, schools, army ports, prisons, large encampments, and tanker supplies in larger cities.

Training Program

Development of seminars for water works operators; some staff sent on international fellowships; use consultant instructors; promote training efforts by local universities and technical institutes.

Technical Assistance

As asked; limited programs.

SPECIMEN SURVEILLANCE PROGRAMS

LEVEL III

SURVEILLANCE OF DRINKING WATER QUALITY

Description

A program intended for those countries that already have established programs in major cities and are seeking to provide surveillance on a broader national or regional scale.

Law and Regulation

Basic legal authority plus well-codified administrative regulations.

Drinking Water Standards

Bacteriological plus turbidity, taste, color, odor, and those chemical parameters mandatory for health.

Standard Methods of Analysis

Appropriate to drinking water standards.

Laboratory

Central water laboratory with capability for complete analyses, provision of key laboratory supplies to water works laboratories, and training programs for laboratory workers; regional laboratories if and as needed.

Sanitary Surveys

Periodically made in urban areas, and a partial rural program, routinely undertaken for new drinking water sources in larger systems.

Approval of Source

As above.

Reporting Requirements

Regulations requiring plants to maintain records of operation. Samples to be submitted periodically to central laboratory.

Design Standards

Publication of informal guidelines, consultation available.

Training

Development of short courses for surveillance and for water works staff members, promotion of training efforts of local educational institutions with financial support, if necessary, and participation of professional staff in international training programs, including study tours and "internships" by senior staff.

Technical Assistance

Advisory services on cross-connections, plumbing, additives, material specifications, and rural water supplies.

Regulation of Special Water Supplies

As for Level II, plus all urban supplies, fairs, markets, housing projects, and larger bottlers and ice manufacturers.

SPECIMEN SURVEILLANCE PROGRAM

LEVEL IV

SURVEILLANCE OF DRINKING WATER QUALITY

Description

Program intended for countries with well-established surveillance programs which seek to extend service nationwide and to increase their scope and effectiveness, particularly those countries that are at the "takeoff point" in economic development.

Laws and Regulations

Complete powers, but advisory rather than mandatory regulations for those activities lacking sufficient staff to properly enforce them. Police power in any situation where clear threat to health can be demonstrated.

Drinking Water Standards

WHO "International Standards for Drinking Water," or equivalent, with appropriate local adaptation and publication.

Standard Methods

WHO "International Standards for Drinking Water," published locally in national language.

Laboratory

Establishment of fully equipped central reference laboratory and regional facilities. Central laboratory to provide many services, including training, technical assistance, bacteriological media, standards, and evaluation of other laboratories.

Sanitary Surveys

All urban areas, including distribution systems; most larger rural community supplies surveyed on an established frequency.

Approval of Sources

All new sources for community water systems require preconstruction approval.

Reporting Requirements

Regulations requiring larger plants to maintain records of operation and of laboratory analyses; samples to be submitted to or taken by surveillance agency on an established schedule.

Design Standards

Formal program for preconstruction approval of new works for largest systems; published guidelines.

Plumbing Code

Codified and enforced in major cities and for major manufacturers of plumbing fixtures.

Training

Strong programs of short courses, support of institutional training and educational programs, and operation of its own technical institute if necessary.

Technical Assistance

Active program with full-time staff.

Regulation of Special Supplies

All supplies serving significant population numbers; regulation of bottled water and ice.

Other

Cross-connection control program, formal participation in health education program of health ministry.