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Surveillance

Drinking-water supply surveillance is “the continuous and vigilant public health assessment and review of the safety and acceptability of drinking-water supplies” (WHO, 1976). This surveillance contributes to the protection of public health by promoting improvement of the quality, quantity, accessibility, coverage, affordability and continuity of water supplies (known as service indicators) and is complementary to the quality control function of the drinking-water supplier. Drinking-water supply surveillance does not remove or replace the responsibility of the drinking-water supplier to ensure that a drinking-water supply is of acceptable quality and meets predetermined health-based and other performance targets.

All members of the population receive drinking-water by some means – including the use of piped supplies with or without treatment and with or without pumping (supplied via domestic connection or public standpipe), delivery by tanker truck or carriage by beasts of burden or collection from groundwater sources (springs or wells) or surface sources (lakes, rivers and streams). It is important for the surveillance agency to build up a picture of the frequency of use of the different types of supply, especially as a preliminary step in the planning of a surveillance programme. There is little to be gained from surveillance of piped water supplies alone if these are available to only a small proportion of the population or if they represent a minority of supplies.

Information alone does not lead to improvement. Instead, the effective management and use of the information generated by surveillance make possible the rational improvement of water supplies – where “rational” implies that available resources are used for maximum public health benefit.

Surveillance is an important element in the development of strategies for incremental improvement of the quality of drinking-water supply services. It is important that strategies be developed for implementing surveillance, collating, analysing and summarizing data and reporting and disseminating the findings and are accompanied by recommendations for remedial action. Follow-up will be required to ensure that remedial action is taken.

Surveillance extends beyond drinking-water supplies operated by a discrete drinking-water supplier to include drinking-water supplies that are managed by

communities and includes assurance of good hygiene in the collection and storage of household water.

The surveillance agency must have, or have access to, legal expertise in addition to expertise on drinking-water and water quality (see section 2.3.1). Drinking-water supply surveillance is also used to ensure that any transgressions that may occur are appropriately investigated and resolved. In many cases, it will be more appropriate to use surveillance as a mechanism for collaboration between public health agencies and drinking-water suppliers to improve drinking-water supply than to resort to enforcement, particularly where the problem lies mainly with community-managed drinking-water supplies.

The authorities responsible for drinking-water supply surveillance may be the public health ministry or other agency (see section 1.2.1), and their roles encompass four areas of activity:

- public health oversight of organized drinking-water supplies;
- public health oversight and information support to populations without access to organized drinking-water supplies, including communities and households;
- consolidation of information from diverse sources to enable understanding of the overall drinking-water supply situation for a country or region as a whole as an input to the development of coherent public health-centred policies and practices; and
- participation in the investigation, reporting and compilation of outbreaks of waterborne disease.

A drinking-water supply surveillance programme should normally include processes for approval of WSPs. This approval will normally involve review of the system assessment, of the identification of appropriate control measures and supporting programmes and of operational monitoring and management plans. It should ensure that the WSP covers normal operating conditions and predictable incidents (deviations) and has contingency plans in case of an emergency or unforeseen event.

The surveillance agency may also support or undertake the development of WSPs for community-managed drinking-water supplies and household water storage. Such plans may be generic for particular technologies rather than specific for individual systems.

5.1 Types of approaches

There are two types of approaches to surveillance of drinking-water quality: audit-based approaches and approaches relying on direct assessment. Implementation of surveillance will generally include a mixture of these approaches according to supply type and may involve using rolling programmes whereby systems are addressed progressively. Often it is not possible to undertake extensive surveillance of all community or household supplies. In these cases, well designed surveys should be undertaken in order to understand the situation at the national or regional level.

5.1.1 Audit

In the audit approach to surveillance, assessment activities, including verification testing, are undertaken largely by the supplier, with third-party auditing to verify compliance. It is increasingly common that analytical services are procured from accredited external laboratories. Some authorities are also experimenting with the use of such arrangements for services such as sanitary inspection, sampling and audit reviews.

An audit approach requires the existence of a stable source of expertise and capacity within the surveillance agency in order to:

- review and approve new WSPs;
- undertake or oversee auditing of the implementation of individual WSPs as a programmed routine activity; and
- respond to, investigate and provide advice on receipt of reports on significant incidents.

Periodic audit of implementation of WSPs is required:

- at intervals (the frequency of routine audits will be dependent on factors such as the size of the population served and the nature and quality of source water / treatment facilities);
- following substantial changes to the source, the distribution or storage system or treatment process; and
- following significant incidents.

Periodic audit would normally include the following elements, in addition to review of the WSP:

- examination of records to ensure that system management is being carried out as described in the WSP;
- ensuring that operational monitoring parameters are kept within operational limits and that compliance is being maintained;
- ensuring that verification programmes are operated by the water supplier (either through in-house expertise or through a third-party arrangement);
- assessment of supporting programmes and of strategies for improvement and updating of the WSP; and
- in some circumstances, sanitary inspection, which may cover the whole of the drinking-water system, including sources, transmission infrastructure, treatment plants, storage reservoirs and distribution systems.

In response to reports of significant incidents, it is necessary to ensure that:

- the event is investigated promptly and appropriately;
- the cause of the event is determined and corrected;

- the incident and corrective action are documented and reported to appropriate authorities; and
- the WSP is reassessed to avoid the occurrence of a similar situation.

The implementation of an audit-based approach places responsibility on the drinking-water supplier to provide the surveillance agency with information regarding system performance against agreed indicators. In addition, a programme of announced and unannounced visits by auditors to drinking-water suppliers should be implemented to review documentation and records of operational practice in order to ensure that data submitted are reliable. Such an approach does not necessarily imply that water suppliers are likely to falsify records, but it does provide an important means of reassuring consumers that there is true independent verification of the activities of the water supplier. The surveillance agency will normally retain the authority to undertake some analysis of drinking-water quality to verify performance or enter into a third-party arrangement for such analysis.

5.1.2 Direct assessment

It may be appropriate for the drinking-water supply surveillance agency to carry out independent testing of water supplies. Such an approach often implies that the agency has access to analytical facilities of its own, with staff trained to carry out sampling, analysis and sanitary inspection.

Direct assessment also implies that surveillance agencies have the capacity to assess findings and to report to and advise suppliers and communities.

A surveillance programme based on direct assessment would normally include:

- specified approaches to large municipality / small municipality / community supplies and individual household supplies;
- sanitary inspections to be carried out by qualified personnel;
- sampling to be carried out by qualified personnel;
- tests to be conducted using suitable methods by accredited laboratories or using approved field testing equipment and qualified personnel; and
- procedures on reporting findings and follow-up to ensure that they have been acted on.

For community-managed drinking-water supplies and where the development of in-house verification or third-party arrangements is limited, direct assessment may be used as the principal system of surveillance. This may apply to drinking-water supplies in small towns by small-scale private sector operators or local government. Direct assessment may lead to the identification of requirements to amend or update the WSP, and the process to be followed when undertaking such amendments should be clearly identified.

Where direct assessment is carried out by the surveillance agency, it complements other verification testing. General guidance on verification testing, which is also applicable to surveillance through direct assessment, is provided in section 4.3.

5.2 Adapting approaches to specific circumstances

5.2.1 Urban areas in developing countries

Drinking-water supply arrangements in urban areas of developing countries are typically complex. There will often be a large piped supply with household and public connections and a range of alternative drinking-water supplies, including point sources and vended water. In these situations, the surveillance programme should take account of the different sources of drinking-water and the potential for deterioration in quality during collection, storage and use. Furthermore, the population will vary in terms of socioeconomic status and vulnerability to water-related disease.

In many situations, zoning the urban area on the basis of vulnerability and drinking-water supply arrangements is required. The zoning system should include all populations within the urban area, including informal and periurban settlements, regardless of their legal status, in order to direct resources to where greatest improvements (or benefits) to public health will be achieved. This provides a mechanism to ensure that non-piped drinking-water sources are also included within drinking-water supply surveillance activities.

Experience has shown that zoning can be developed using qualitative and quantitative methods and is useful in identifying vulnerable groups and priority communities where drinking-water supply improvements are required.

5.2.2 Surveillance of community drinking-water supplies

Small community-managed drinking-water supplies are found in most countries and may be the predominant form of drinking-water supply for large sections of the population. The precise definition of a “community drinking-water supply” will vary, but administration and management arrangements are often what set community supplies apart. Community-managed supplies may include simple piped water systems or a range of point sources, such as boreholes with hand pumps, dug wells and protected springs.

The control of water safety and implementation of surveillance programmes for such supplies often face significant constraints. These typically include:

- limited capacity and skills within the community to undertake process control and verification; this may increase the need both for surveillance to assess the state of drinking-water supplies and for surveillance staff to provide training and support to community members; and
- the very large number of widely dispersed supplies, which significantly increases overall costs in undertaking surveillance activities.

Furthermore, it is often these supplies that present the greatest water quality problems.

Experience from both developing and developed countries has shown that surveillance of community-managed drinking-water supplies can be effective when well designed and when the objectives are geared more towards a supportive role to

enhance community management and evaluation of overall strategies to their support than towards enforcement of compliance.

Surveillance of community drinking-water supplies requires a systematic programme of surveys that encompass all aspects of the drinking-water supply to the population as a whole, including sanitary inspection (including catchments) and institutional and community aspects. Surveillance should address variability in source water quality, treatment process efficacy and the quality of distributed or household-treated and household-stored water.

Experience has also shown that the role of surveillance may include health education and health promotion activities to improve healthy behaviour and management of drinking-water supply and sanitation. Participatory activities can include sanitary inspection by communities and, where appropriate, community-based testing of drinking-water quality using affordable field test kits and other accessible testing resources.

In the evaluation of overall strategies, the principal aim should be to derive overall lessons for improving water safety for all community supplies, rather than relying on monitoring the performance of individual supplies.

Frequent visits to every individual supply may be impractical because of the very large numbers of such supplies and the limitations of resources for such visits. However, surveillance of large numbers of community supplies can be achieved through a rolling programme of visits. Commonly, the aim will be to visit each supply periodically (once every 3–5 years at a minimum) using either stratified random sampling or cluster sampling to select specific supplies to be visited. During each visit, sanitary inspection and water quality analysis will normally be done to provide insight to contamination and its causes.

During each visit, testing of water stored in the home may be undertaken in a sample of households. The objective for such testing is to determine whether contamination occurs primarily at the source or within the home. This will allow evaluation of the need for investment in supply improvement or education on good hygiene practices for household treatment and safe storage. Household testing may also be used to evaluate the impact of a specific hygiene education programme.

5.2.3 Surveillance of household treatment and storage systems

Where water is handled during storage in households, it may be vulnerable to contamination, and sampling of household-stored water is of interest in independent surveillance. It is often undertaken on a “survey” basis to develop insights into the extent and nature of prevailing problems.

Surveillance systems managed by public health authorities for drinking-water supplies using household treatment and household storage containers are therefore recommended. The principal focus of surveillance of household-based interventions will be assessment of their acceptance and impact through sample surveys so as to evaluate and inform overall strategy development and refinement.

5.3 Adequacy of supply

As the drinking-water supply surveillance agency has an interest in the health of the population at large, its interest extends beyond water quality to include all aspects of the adequacy of drinking-water supply for the protection of public health.

In undertaking an assessment of the adequacy of the drinking-water supply, the following basic service parameters of a drinking-water supply should normally be taken into consideration:

- *Quality*: whether the supply has an approved WSP (see chapter 4) that has been validated and is subject to periodic audit to demonstrate compliance (see chapter 3);
- *Quantity (service level)*: the proportion of the population using water from different levels of drinking-water supply (e.g., no access, basic access, intermediate access and optimal access);
- *Accessibility*: the percentage of the population that has reasonable access to an improved drinking-water supply;
- *Affordability*: the tariff paid by domestic consumers; and
- *Continuity*: the percentage of the time during which drinking-water is available (daily, weekly and seasonally).

5.3.1 Quantity (service level)

The quantity of water collected and used by households has an important influence on health. There is a basic human physiological requirement for water to maintain adequate hydration and an additional requirement for food preparation. There is a further requirement for water to support hygiene, which is necessary for health.

Estimates of the volume of water needed for health purposes vary widely. In deriving WHO guideline values, it is assumed that the daily per capita consumption of drinking-water is approximately 2 litres for adults, although actual consumption varies according to climate, activity level and diet. Based on currently available data, a minimum volume of 7.5 litres per capita per day will provide sufficient water for hydration and incorporation into food for most people under most conditions. In addition, adequate domestic water is needed for food preparation, laundry and personal and domestic hygiene, which are also important for health. Water may also be important in income generation and amenity uses.

The quantities of water collected and used by households are primarily a function of the distance to the water supply or total collection time required. This broadly equates to the level of service. Four levels of service can be defined, as shown in Table 5.1.

Service level is a useful and easily measured indicator that provides a valid surrogate for the quantity of water collected by households and is the preferred indicator for surveillance. Available evidence indicates that health gains accrue from improving

Table 5.1 Service level and quantity of water collected

Service level	Distance/time	Likely volumes of water collected	Public health risk from poor hygiene	Intervention priority and actions
No access	More than 1 km / more than 30 min round-trip	Very low – 5 litres per capita per day	Very high Hygiene practice compromised Basic consumption may be compromised	Very high Provision of basic level of service Hygiene education
Basic access	Within 1 km / within 30 min round-trip	Average approximately 20 litres per capita per day	High Hygiene may be compromised Laundry may occur off-plot	High Hygiene education Provision of improved level of service
Intermediate access	Water provided on-plot through at least one tap (yard level)	Average approximately 50 litres per capita per day	Low Hygiene should not be compromised Laundry likely to occur on-plot	Low Hygiene promotion still yields health gains Encourage optimal access
Optimal access	Supply of water through multiple taps within the house	Average 100–200 litres per capita per day	Very low Hygiene should not be compromised Laundry will occur on-plot	Very low Hygiene promotion still yields health gains

Source: Howard & Bartram (2003)

service level in two key stages: the delivery of water within 1 km or 30 min total collection time; and when supplied to a yard level of service. Further health gains are likely to occur once water is supplied through multiple taps, as this will increase water availability for diverse hygiene practices. The volume of water collected may also depend on the reliability and cost of water. Therefore, collection of data on these indicators is important.

5.3.2 Accessibility

From the public health standpoint, the proportion of the population with reliable access to safe drinking-water is the most important single indicator of the overall success of a drinking-water supply programme.

There are a number of definitions of access (or coverage), many with qualifications regarding safety or adequacy. The preferred definition is that used by WHO and UNICEF in their “Joint Monitoring Programme,” which defines “reasonable access” to improved sources as being “availability of at least 20 litres per person per day within one kilometre of the user’s dwelling.” Improved and unimproved water supply technologies in the WHO/UNICEF Joint Monitoring Programme have been defined in terms of providing “reasonable access,” as summarized below:

- **Improved water supply technologies:**
 - Household connection
 - Public standpipe
 - Borehole
 - Protected dug well
 - Protected spring
 - Rainwater collection
- **Unimproved water supply technologies:**
 - Unprotected well
 - Unprotected spring
 - Vendor-provided water
 - Bottled water
 - Tanker truck provision of water.

5.3.3 Affordability

The affordability of water has a significant influence on the use of water and selection of water sources. Households with the lowest levels of access to safe water supply frequently pay more for their water than do households connected to a piped water system. The high cost of water may force households to use alternative sources of water of poorer quality that represent a greater risk to health. Furthermore, high costs of water may reduce the volumes of water used by households, which in turn may influence hygiene practices and increase risks of disease transmission.

When assessing affordability, it is important to collect data on the price at the point of purchase. Where households are connected to the drinking-water supplier, this will be the tariff applied. Where water is purchased from public standpipes or from neighbours, the price at the point of purchase may be very different from the drinking-water supplier tariff. Many alternative water sources (notably vendors) also involve costs, and these costs should be included in evaluations of affordability. In addition to recurrent costs, the costs for initial acquisition of a connection should also be considered when evaluating affordability.

5.3.4 Continuity

Interruptions to drinking-water supply either through intermittent sources or resulting from engineering inefficiencies are a major determinant of the access to and quality of drinking-water. Analysis of data on continuity of supply requires the consideration of several components. Continuity can be classified as follows:

- year-round service from a reliable source with no interruption of flow at the tap or source;
- year-round service with frequent (daily or weekly) interruptions, of which the most common causes are:

- restricted pumping regimes in pumped systems, whether planned or due to power failure or sporadic failure;
- peak demand exceeding the flow capacity of the transmission mains or the capacity of the reservoir;
- excessive leakage within the distribution systems;
- excessive demands on community-managed point sources;
- seasonal service variation resulting from source fluctuation, which typically has three causes:
 - natural variation in source volume during the year;
 - volume limitation because of competition with other uses such as irrigation;
 - periods of high turbidity when the source water may be untreatable; and
- compounded frequent and seasonal discontinuity.

This classification reflects broad categories of continuity, which are likely to affect hygiene in different ways. Daily or weekly discontinuity results in low supply pressure and a consequent risk of in-pipe recontamination. Other consequences include reduced availability and lower volume use, which adversely affect hygiene. Household water storage may be necessary, and this may lead to an increase in the risk of contamination during such storage and associated handling. Seasonal discontinuity often forces users to obtain water from inferior and distant sources. As a consequence, in addition to the obvious reduction in quality and quantity, time is lost in water collection.

5.4 Planning and implementation

For drinking-water supply surveillance to lead to improvements in drinking-water supply, it is vital that the mechanisms for promoting improvement are recognized and used.

The focus of drinking-water supply improvement (whether as investment priority at regional or national levels, development of hygiene education programmes or enforcement of compliance) will depend on the nature of the drinking-water supplies and the types of problems identified. A checklist of mechanisms for drinking-water supply improvement based on the output of surveillance is given below:

- **Establishing national priorities** – When the most common problems and shortcomings in drinking-water systems have been identified, national strategies can be formulated for improvements and remedial measures; these might include changes in training (of managers, administrators, engineers or field staff), rolling programmes for rehabilitation or improvement or changes in funding strategies to target specific needs.
- **Establishing regional priorities** – Regional offices of drinking-water supply agencies can decide which communities to work in and which remedial activities are priorities; public health criteria should be considered when priorities are set.

- **Establishing hygiene education programmes** – Not all of the problems revealed by surveillance are technical in nature, and not all are solved by drinking-water suppliers; surveillance also looks at problems involving community and household supplies, water collection and transport and household treatment and storage. The solutions to many of these problems are likely to require educational and promotional activities.
- **Auditing of WSPs and upgrading** – The information generated by surveillance can be used to audit WSPs and to assess whether these are in compliance. Systems and their associated WSPs should be upgraded where they are found to be deficient, although feasibility must be considered, and enforcement of upgrading should be linked to strategies for progressive improvement.
- **Ensuring community operation and maintenance** – Support should be provided by a designated authority to enable community members to be trained so that they are able to assume responsibility for the operation and maintenance of community drinking-water supplies.
- **Establishing public awareness and information channels** – Publication of information on public health aspects of drinking-water supplies, water quality and the performance of suppliers can encourage suppliers to follow good practices, mobilize public opinion and response and reduce the need for regulatory enforcement, which should be an option of last resort.

In order to make best use of limited resources where surveillance is not yet practised, it is advisable to start with a basic programme that develops in a planned manner. Activities in the early stages should generate enough useful data to demonstrate the value of surveillance. Thereafter, the objective should be to progress to more advanced surveillance as resources and conditions permit.

The activities normally undertaken in the initial, intermediate and advanced stages of development of drinking-water supply surveillance are summarized as follows:

- **Initial phase:**
 - Establish requirements for institutional development.
 - Provide training for staff involved in programme.
 - Define the role of participants, e.g., quality assurance / quality control by supplier, surveillance by public health authority.
 - Develop methodologies suitable for the area.
 - Commence routine surveillance in priority areas (including inventories).
 - Limit verification to essential parameters and known problem substances.
 - Establish reporting, filing and communication systems.
 - Advocate improvements according to identified priorities.
 - Establish reporting to local suppliers, communities, media and regional authorities.
 - Establish liaison with communities; identify community roles in surveillance and means of promoting community participation.

- **Intermediate phase:**

- Train staff involved in programme.
- Establish and expand systematic routine surveillance.
- Expand access to analytical capability (often by means of regional laboratories, national laboratories being largely responsible for analytical quality control and training of regional laboratory staff).
- Undertake surveys for chemical contaminants using wider range of analytical methods.
- Evaluate all methodologies (sampling, analysis, etc.).
- Use appropriate standard methods (e.g., analytical methods, fieldwork procedures).
- Develop capacity for statistical analysis of data.
- Establish national database.
- Identify common problems, promote activities to address them at regional and national levels.
- Expand reporting to include interpretation at national level.
- Draft or revise health-based targets as part of framework for safe drinking-water.
- Use legal enforcement where necessary.
- Involve communities routinely in surveillance implementation.

- **Advanced phase:**

- Train staff involved in programme.
- Establish routine testing for all health and acceptability parameters at defined frequencies.
- Use full network of national, regional and local laboratories (including analytical quality control).
- Use national framework for drinking-water safety.
- Improve water services on the basis of national and local priorities, hygiene education and enforcement of standards.
- Establish regional database archives compatible with national database.
- Disseminate data at all levels (local, regional and national).
- Involve communities routinely in surveillance implementation.

5.5 Reporting and communicating

An essential element of a successful surveillance programme is the reporting of results to stakeholders. It is important to establish appropriate systems of reporting to all relevant bodies. Proper reporting and feedback will support the development of effective remedial strategies. The ability of the surveillance programme to identify and advocate interventions to improve water supply is highly dependent on the ability to analyse and present information in a meaningful way to different target audiences. The target audiences for surveillance information will typically include:

- public health officials at local, regional and national levels;
- water suppliers;
- local administrations;
- communities and water users; and
- local, regional and national authorities responsible for development planning and investment.

5.5.1 Interaction with community and consumers

Community participation is a desirable component of surveillance, particularly for community and household drinking-water supplies. As primary beneficiaries of improved drinking-water supplies, community members have a right to take part in decision-making. The community represents a resource that can be drawn upon for local knowledge and experience. They are the people who are likely to first notice problems in the drinking-water supply and therefore can provide an indication of when immediate remedial action is required. Communication strategies should include:

- provision of summary information to consumers (e.g., through annual reports or the Internet); and
- establishment and involvement of consumer associations at local, regional and national levels.

The right of consumers to information on the safety of the water supplied to them for domestic purposes is fundamental.

However, in many communities, the simple right of access to information will not ensure that individuals are aware of the quality or safety of the water supplied to them. The agencies responsible for surveillance should develop strategies for disseminating and explaining the significance of results obtained.

It may not be feasible for the surveillance agency to provide feedback information directly to the entire community. Thus, it may be appropriate to use community organizations, where these exist, to provide an effective channel for providing feedback information to users. Some local organizations (e.g., local councils and community-based organizations, such as women's groups, religious groups and schools) have regular meetings in the communities that they serve and can therefore provide a mechanism of relaying important information to a large number of people within the community. Furthermore, by using local organizations, it is often easier to initiate a process of discussion and decision-making within the community concerning water quality. The most important elements in working with local organizations are to ensure that the organization selected can access the whole community and can initiate discussion on the results of surveillance.

5.5.2 Regional use of data

Strategies for regional prioritization are typically of a medium-term nature and have specific data requirements. While the management of information at a national level

is aimed at highlighting common or recurrent problems, the objective at a regional level is to assign a degree of priority to individual interventions. It is therefore important to derive a relative measure of health risk. While this information cannot be used on its own to determine which systems should be given immediate attention (which would also require the analysis of economic, social, environmental and cultural factors), it provides an extremely important tool for determining regional priorities. It should be a declared objective to ensure that remedial action is carried out each year on a predetermined proportion of the systems classified as high risk.

At the regional level, it is also important to monitor the improvement in (or deterioration of) both individual drinking-water supplies and the supplies as a whole. In this context, simple measures, such as the mean sanitary inspection score of all systems, the proportion of systems with given degrees of faecal contamination, the population with different levels of service and the mean cost of domestic consumption, should be calculated yearly and changes monitored.

In many developing and developed countries, a high proportion of small-community drinking-water systems fail to meet requirements for water safety. In such circumstances, it is important that realistic goals for progressive improvement are agreed upon and implemented. It is practical to classify water quality results in terms of an overall grading for water safety linked to priority for action, as illustrated in Table 5.2.

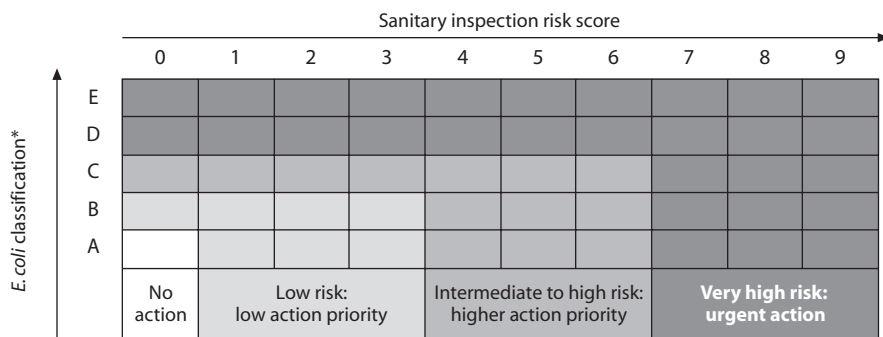
Grading schemes may be of particular use in community supplies where the frequency of testing is low and reliance on analytical results alone is especially inappropriate. Such schemes will typically take account of both analytical findings and results of the sanitary inspection through schema such as illustrated in Figure 5.1.

Combined analysis of sanitary inspection and water quality data can be used to identify the most important causes of and control measures for contamination. This is important to support effective and rational decision-making. For instance, it will be important to know whether on-site or off-site sanitation could be associated with contamination of drinking-water, as the remedial actions required to address either source of contamination will be very different. This analysis may also identify other factors associated with contamination, such as heavy rainfall. As the data will be non-parametric, suitable methods for analysis include chi-square, odds ratios and logistic regression models.

Table 5.2 Categorization of drinking-water systems based on compliance with performance and safety targets (see also Table 7.7)

Quality of water system	Proportion (%) of samples negative for <i>E. coli</i>		
	<5000	Population size: 5000–100 000	>100 000
Excellent	90	95	99
Good	80	90	95
Fair	70	85	90
Poor	60	80	85

Figure 5.1 Example of assessment of priority of remedial actions of community drinking-water supplies based on a grading system of microbial quality and sanitary inspection rating or score



* Based on frequency of *E. coli* positivity in drinking-water and/or *E. coli* concentrations in drinking-water.

Grading	Description
A	Completely satisfactory, extremely low level of risk
B	Satisfactory, very low level of risk
C	Marginally satisfactory, low level of microbial risk when water leaves the plant, but may not be satisfactory chemically
D	Unsatisfactory level of risk
E	Unacceptable level of risk

Source: Lloyd & Bartram (1991)