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Environmental Microbial Monitoring, Surveillance and Disease Outbreaks

[1] Oke Oluwafemi Johnson, [2] Ojile Martha Oyilonye, [3] Anih Chinaza Doris, [4] Ugwu Chidera Agatha, [5] Omaha Nnenna Ogbonnaya, [6] Udeagu Ugochukwu Franklin, [7] Idubor Precious Osariemen, [8] Ibe Margaret Chinazam, [9] Ali Casmir Kasiemobi, [10] Nwebor Chidera Stephen, [11] Okpara Friday, [12] Ugwuanyi Collins Chidiebere, [13] Okafor Maryrose Chikaosolu, [14] Onuchukwu Ifunanyachukwu Confidence, [15] Damilohun Oluwaseun, [16] Simon Ezekiel Okewu, [17] Arinze Ozokoye, [18] Adenuga Oreofe Oluwatoyin, [19] Eze Williams Ezebuilo, [20] Lilian Chukwu, [21] Ogunledun Adesola Oluwakemi, [22] Okolie Nnabuike Alieze, [23] Obi Uzoamaka Lilian

[1] Department of Microbiology, Obafemi Awolowo University, Osun State, Nigeria
[2, 3, 4] Department of Nursing, People's Friendship University of Russia (RUDN), Moscow, Russia
[5] Department of Medical Laboratory Science, Abia State University, Uturu, Abia State, Nigeria
[6] Medical Laboratory Science, Enugu State University of Science and Technology, Enugu State, Nigeria
[7] Faculty of Pharmacy, University of Benin, Edo State, Nigeria
[8, 9, 10, 11, 19] Medical Laboratory Science Department, Ebonyi State University, Abakaliki. Ebonyi State, Nigeria
[12] Department of Medical Radiography and Radiological Sciences, University of Nigeria, Enugu Campus, Nigeria
[13] Department of Biotechnology, I.M Sechenov First Moscow State Medical University, Moscow, Russia
[14, 18, 20, 21, 22] F. Erismann Institute of Public Health, I.M Sechenov First Moscow State Medical University, Moscow, Russia
[15] Department of Science Education, University of Lagos Akoka Yaba, Lagos State, Nigeria
[16] Department of Human Anatomy, Federal University of Lafia. Nasarawa State, Nigeria
[17] Department of Medical Laboratory Science, University of Nigeria, Enugu State, Nigeria
[23] Department of Anatomy, Ebonyi State University, Abakaliki. Ebonyi State, Nigeria

Corresponding Author: **Ugwu Chidera Agatha**

Abstract

This review explores the important role of environmental monitoring and outbreak investigation in protecting public health. Effective surveillance systems, which integrate laboratory-based reporting and active public involvement, are fundamental for the early detection and effective response to disease outbreaks. Descriptive epidemiology is utilized to characterize outbreaks by analyzing patterns of incidence and distribution, which aids in identifying potential sources of infection and formulating targeted control measures. Environmental investigations, encompassing site inspections and laboratory analyses, are essential for accurately pinpointing contamination sources and understanding the environmental conditions that facilitate disease transmission. A comprehensive approach to outbreak management is necessary to address the complex dynamics of disease spread. This involves targeting the immediate source of contamination, understanding and disrupting transmission pathways, and implementing measures to protect vulnerable populations. Control strategies must be multifaceted, combining immediate interventions with longer-term public health initiatives to prevent recurrence and mitigate impact. Effective communication is a cornerstone of successful outbreak management. Engaging the public with clear and timely information, and coordinating response efforts among public health agencies, healthcare providers, and community organizations, are crucial for managing outbreaks efficiently. This requires robust communication strategies that ensure all stakeholders are informed and able to act on the latest guidance and updates. A proactive stance in public health surveillance and response is essential for safeguarding community health and mitigating the broader impacts of disease outbreaks.

Keywords: Outbreak Investigation, Environmental Monitoring, Public Health, Surveillance, Disease Control

Introduction

The term 'outbreak' has been defined as "an epidemic limited to a localized increase in the incidence of a disease, e.g., in a village, town, or closed institution" [1]. The term 'epidemic' is defined as "the occurrence in a community or region of cases of an illness, specific health-related behaviour, or other health-related events clearly in excess of normal expectancy." [2]. An outbreak is the occurrence of cases of an illness, specific health-related behavior, or other health related event clearly in excess

of normal expectancy in a given community, district, region or facility for a given period of time [3]. An outbreak may be a single case of a communicable disease long absent from a population (e.g., measles) or the first invasion by a disease in an area (e.g., SARS) that requires immediate response [3]. The number of cases required to declare an outbreak will vary depending on the infectious agent, the size and type of the population exposed, previous exposure or lack of exposure to the disease, and time and place of occurrence [4].

A pandemic is defined as a worldwide epidemic that, according to the World Health Organization (WHO), has to meet three conditions:

- The microbe infects and causes serious illness in humans.
- Humans do not have immunity against the virus and
- The pathogen spreads easily from person-to-person and survives within humans. The terms 'virulence' and 'mortality' are not mentioned in the current WHO definition, although these factors have previously been included (WHO, 2005) (Fig 1).

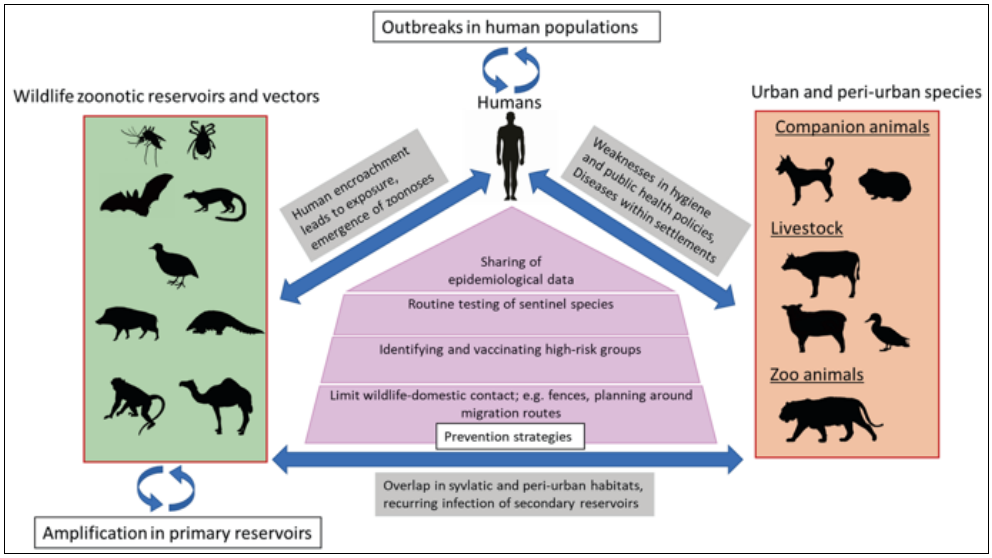

Fig 1: Schematic overview of the circular interaction between wildlife (green box) and urban (orange box) zoonotic infection reservoirs and the human population. Overview of zoonotic infection pathways between domesticated and non-domesticated (i.e., wildlife) animals and humans.

Reasons for investigating outbreaks

While outbreak control is of paramount importance, the benefits of effective outbreak management range beyond the immediate need to stop the outbreak progressing. Key benefits are listed below.

To halt the outbreak and prevent further illness

The most compelling reason to investigate an outbreak is that exposure to the outbreak source may be continuing, and by restricting transmission from the source of illness, further cases can be prevented [5]. The importance of rapid outbreak investigation and the implementation of control measures are clearly stated in a South Australian coroner's report on the death of a child during an outbreak of haemolytic-uraemic syndrome associated with *Escherichia coli* O111-contamination of a meat product in 1995 [6]. The coroner strongly criticized the PHS for a two-day delay to the investigation and a three-day delay to the analysis of the findings [6].

To prevent further outbreaks from the immediate source

Even if an outbreak is essentially over by the time the investigation begins, investigation is necessary to find out why the outbreak occurred, and to prevent it happening again.

To prevent further outbreaks from other similar sources

Outbreak investigation may disclose a systematic error, leading to the exposure of people to disease agents. Knowledge gained from outbreak management may help to improve standard process guidelines [5].

To address public concerns

Disease outbreaks often attract considerable publicity. Public concern or even outrage is likely to increase if the public health agency responsible is seen to be ignoring concerns about a perceived disease outbreak [7]. One of the most important steps towards addressing public concern is to acknowledge and investigate issues that are perceived to pose a risk to the public. Risk communication is an important tool in this regard.

To involve the public in disease control

Risk and outbreak communication is also about providing information regarding the situation, advising on what actions people can take and listening to the community. Well-communicated judicious communication can help with disease control.

To reduce direct and indirect costs

Prompt and timely outbreak responses can be economically beneficial by reducing health service expenditure, work absenteeism, child care costs and costs associated with the inability to meet unpaid responsibilities [8].

To identify new mechanisms of transmission of known illnesses

Information gained from outbreak investigation has provided early warnings about new transmission mechanisms by which people can become exposed to disease agents, and has provided a springboard for their comprehensive study [9]. Examples include identification of the hazards involved with new food products.

To identify new or emerging disease agents

Several new disease agents are first identified through the investigation of outbreaks of unexplained illness [10]. Notable examples include the human immunodeficiency virus (HIV) that causes acquired immunodeficiency syndrome (AIDS) and Legionella spp. that cause Legionnaires' disease [11].

To satisfy legal and international obligations

The investigation and control of cases of notifiable diseases are the obligations of the medical officers of health under the Health Act. Increasingly, outbreaks cross national borders [12], and appropriate management supports various countries contribution to international communicable disease surveillance and control, especially if the disease is appropriate for eradication [13]. New Zealand has obligations under the revised International Health Regulations10 to report certain disease outbreaks and public health events [10].

To help train public health staff

Staff training is an on-going responsibility. Outbreak management skills are best learnt while involved in actual outbreak situations, under appropriate supervision. Management of 'routine' small-scale outbreaks can provide staff with the experience and confidence necessary to effectively manage large-scale, high-profile outbreaks.

Types of outbreaks

There are several types of outbreaks, reflecting differences in the way case exposures are grouped. The definitions of outbreak types given next are consistent with those used for outbreak reporting under the notifiable disease surveillance system – EpiSurv [14]. In practice, however, outbreak types may not be mutually exclusive. Several outbreak types may comprise a single outbreak, although one type usually predominates [15].

Common event

An outbreak due to exposure of a group of persons to a noxious influence that is common to the individuals in the group, where the exposure is brief and essentially simultaneous and all resultant cases develop within one incubation period of the disease [16]. Cases have exposures that occur at virtually the same place and time. Common examples include weddings, sports events, or any other event that occurs within a specified time period. Examples of this type of outbreak have been reported in New Zealand [17].

Dispersed common source

Hereafter described as dispersed outbreaks, these outbreaks are due to exposure of a group of persons in a community to a noxious influence that is common to the individuals in the group, where exposures have not all occurred around the same place or necessarily around the same time [18]. These outbreaks are often due to the consumption of a widely distributed vehicle of infection transmission, such as a contaminated food product or reticulated drinking-water [19]. The 2009 outbreak of *Salmonella typhimurium* phage type 1 associated with watermelon in Gisborne is an example of a dispersed outbreak [20].

Common source in a specific place (or site)

Hereafter described as common site outbreaks, these outbreaks are due to the exposure of a group of persons in a community to a noxious influence that is common to the individuals in the group, and where all the exposures have occurred at the same place, but not at the same time [21]. Typical examples include those where exposures have occurred within the setting of a single swimming pool, restaurant, cruise ship, workplace or farm. The July 2006 outbreak of gastroenteritis caused by waterborne norovirus at a New York ski resort is an example of this type of outbreak [22].

Community-wide

An outbreak affecting individuals in a community, where transmission predominantly occurs by direct exposure of susceptible people to infectious people.

Institutional

An outbreak confined to the population of a specific residential or other institutional setting, such as a hospital, rest home, prison or boarding school. An outbreak of Lassa fever in a community in Osun state in 2018 is an example of an institutional outbreak [23].

Many institutional outbreaks are reported globally each year, but most are not published or available in the public domain. In 2010, 606 outbreaks were notified, 277 of which were in institutions. Enteric viruses were the infectious agent in almost one-third of all outbreaks, and the majority (85.3%) of these were caused by norovirus [24].

Household

An outbreak confined to members of a single household. Household outbreaks probably occur frequently, but are likely to be under-reported. In 2010, 229 household outbreaks involving 1,034 cases were reported, that is, 37.8% of all outbreak settings were 'household', making them more commonly reported than those outbreaks set in restaurants (13.4%) and rest homes (11.4%) [25]. The distinctions between these main types of outbreaks are mainly drawn from the distribution of exposures over time and place. In general, common event and household outbreaks are associated with brief and highly localized exposures. Institutional and environmental outbreaks are also localized, but exposures may occur over a prolonged period. By definition, dispersed and communitywide outbreaks have widespread exposures, and may occur over a brief or prolonged time period [26].

Surveillance to detect outbreak

Disease surveillance is the continuous collection, analysis, interpretation of data and the timely dissemination of that information to those who need to know [27]. Surveillance is used to determine the extent and risk of disease transmission. The reports are collected for the purpose of noting changes in disease trends to allow for implementing disease prevention and control strategies that will decrease the burden of illness and the possibility of an outbreak. Prevention and control measures must be applied effectively and efficiently to minimize the burden of disease [28].

Communicable disease surveillance is achieved by health professionals who carry out the following activities:

1. Identify and describe each individual who has acquired a communicable disease
2. Determine the source of the infection
3. Identify exposed individuals to whom the infection may have been transmitted
4. Specify the frequency and pattern of occurrence of infection in population groups at risk by person, place and time
5. Identify populations that are experiencing or may experience an increased frequency of infection
6. Prepare and distribute surveillance reports to health professionals [29].

Disease notifications and other formal surveillance

Most cases of illness reported to the WHO or CDC occur as apparently isolated or 'sporadic' cases of illness without obvious connections to each other [9]. A source of infection is rarely conclusively identified by an investigation of a single sporadic case of disease. Every sporadic case of

illness should, however, be seen as part of an unrecognized outbreak potentially, and details should be documented with this in mind [1]. Standardized interviews of a number of sporadic cases may be useful in generating hypotheses about possible common sources of illness among cases that did not previously appear to be associated [3].

The Centre of disease control and prevention staff of various institutions are responsible for delivering core public health services, including the management and containment of outbreaks of communicable diseases [30]. For each notified case, the relevant EpiSurv Case Report Form should be completed. A review of this information may reveal commonalities among cases and provide clues to a common source of infection. It is important, however, not to over-interpret these findings as commonalities may only indicate a high prevalence of the exposure or activity in the community.

1. Identification of other cases among household and other contacts of the index case for the purposes of providing preventive treatment (i.e., prophylaxis or immunization), and if appropriate, informing them of their exposure and helping them to avoid spreading the disease unknowingly
2. Education to prevent future occurrences of disease
3. Collection of further information to improve the understanding of the disease in the community.

Other than the EpiSurv disease notification system and EARS, formal surveillance systems that may identify sporadic disease cases that are part of an outbreak include laboratory-based reporting and surveillance, sentinel surveillance, notably for influenza, and the sexually-transmitted infections (STI) surveillance system [8]. It is also important to appreciate the importance of and maintain links with the veterinary surveillance systems in this context.

Laboratory-based reporting and surveillance

Accurate and timely data are essential if we are to promptly identify and respond to important public health events such as pandemic influenza, or a similar emergent infectious agent with epidemic or pandemic potential. The Health Amendment Act 2006 was aimed at improving the Government's ability to respond to an outbreak of pandemic flu or a similar highly infectious disease [4]. It also introduced the requirement for laboratories to directly notify to medical officers of health test results indicating the possibility of a notifiable disease. The old legislation (prior to 18 December 2007) saw considerable variations in reporting rates and some under-reporting. The new legislative requirements aimed to improve the old system, and provided for direct laboratory notification of notifiable diseases [5]. This is expected to support reporting by clinicians and result in more comprehensive and faster overall reporting of communicable diseases. Advantages of this system are that medical officers of health may receive notifications in a more comprehensive and timely manner than was the case under the previous system that relied solely on medical practitioner-based reporting. Disadvantages of this system are that many notified laboratory results may be false-positives (i.e., may not actually indicate a case of notifiable disease), and that public health staff may be in the position of starting the investigation before the patient's clinician has communicated the diagnosis to the patient [8]. A further possibility that needs to be avoided is that clinicians may not notify believing that laboratory notification has already been done. Laboratory notification currently occurs either by manual or electronic methods but progress to a national electronic system is now a reality.

Self-reported cases of illness

Cases of illness that are directly reported by a member of the public to the PHS make an important contribution to outbreak detection because there may be substance to the complainants claim that "something (or somebody) caused the illness", and complainants tend to report promptly, so the trail may be warm. The complainant may be aware of other cases of illness and therefore be signalling the outbreak itself.

Many PHSs have protocols for recording information about self-reported illness. Most cases will be enteric disease, and can be recorded in EpiSurv on the Enteric Disease Case Report Form. The basics are that, in recording a complaint of illness reported to a PHS, it is important to collect contact details (such as name, address and phone/fax numbers) and then to systematically collect the following information [16]:

a) What is the person's problem (e.g., clinical description of the illness, whether a health professional was consulted, whether any tests were performed or treatments provided).
b) Who else became ill, what are their characteristics (e.g., age, sex, occupation) and what is the nature of their illness (e.g., symptoms, whether any persons were hospitalised or died)
c) When did the affected person(s) become unwell
d) How can the affected persons be contacted (including names and telephone numbers)
e) How do they think that they became ill (e.g., risk factors, suspected exposures, suspected modes of transmission, hints from others who did or did not become ill)?

Collect as much information as possible from the person reporting an illness the first time contact is made, as it may be difficult to make contact again. If the complainant cannot provide critical pieces of information, try to find out who may be a more appropriate information source and contact that person. Collect information on pertinent negative as well as positive information (e.g., absence as well as presence of particular symptoms).

All cases of self-reported communicable disease require advice to prevent transmission of illness to others (e.g., hygiene instructions). Further control measures may be required in special circumstances, such as the presence of enteric disease in a food handler, communicable disease in a child attending an early childhood centre or indications of adulterated food presenting an imminent danger [17].

Informally-reported suspected outbreaks

As mentioned previously, informal reports of suspected outbreaks are a very common method of outbreak identification. Suspected outbreaks can be reported by:

1. Members of the public
2. Health care workers
3. Service providers, such as operators of food premises or camps
4. Institutions, such as schools, prisons, rest homes
5. Infection control staff [29].

Collect detailed information from individuals reporting a suspected outbreak. Use a similar framework to that discussed previously for self-reported illness, paying particular attention to collecting information on the:

a) Type of illness
b) Number of people thought to be unwell
c) Name and contact details of the individual reporting the outbreak
d) Name and contact details of an individual (if any) responsible for organising the event (if associated with an event)
e) Suspected source of illness.

Outbreak description

This is the descriptive stage of the investigation of an outbreak once it has been confirmed. This is done by collecting and examining information from cases [16]. The goal of the descriptive stage of the investigation is to provide sufficient information to make preliminary control recommendations and to develop hypotheses for further analytical investigation, if required. Despite the sense of urgency that surrounds identification of an outbreak, the investigation should proceed in a planned strategic manner [20]. Existence of a previously developed district outbreak plan will greatly ease this process.

This steps below describes the steps that should be taken in planning the outbreak investigation and describing the outbreak.

Step 1: Compile information collected

Before convening the first outbreak team meeting, compilation of all the routinely-collected information on the cases that have been initially reported, including incomplete information on suspected cases would be done. It is essential to keep EpiSurv as up-to-date as possible for local and national monitoring of outbreaks by a number of agencies [10].

This information is reviewed so that the basis of the outbreak is clear. Identifying the common features about the cases that suggest that they are involved in the outbreak. This information will be used to produce a case definition.

Step 2: Develop a case definition

A case definition is a standardised description of the disease associated with an outbreak which, for the purposes of the investigation, will be used to distinguish between cases and non-cases [19]. The case definition should not be used as a basis for clinical diagnosis, treatment or other management of individuals.

The primary objective in developing a case definition is to include as many individuals as possible who are likely to be part of the outbreak (sensitivity), while excluding as many as possible who are not likely to be part of the outbreak (specificity). This balancing act always involves trade-offs [21].

Step 3: Find other potential cases

Identify additional cases by searching for people who might meet the case definition. This step is undertaken to ensure recognition of the true scale of the outbreak

Step 4: Collect information about cases

Detailed information on all cases involved in an outbreak should be collected using a structured interview based on a standardized questionnaire. The questionnaire should cover disease manifestations, patient characteristics and exposures that may be sources of infection.

Step 5: Perform descriptive analysis of cases

Descriptive analysis is extremely valuable in helping to identify hypotheses about the source of the outbreak that will be useful to guide a full analytic investigation. This information may also be sufficient in itself to help identify ways to control the outbreak.

Step 6: Draw an epidemic curve

An epidemic curve depicts the time course of the onset of symptoms among cases in an outbreak. The epidemic curve is a two-dimensional bar graph or histogram with an x- and a y-axis that helps to illustrate the dynamics of the outbreak, including the number of people affected the time course of the outbreak and whether the outbreak is continuing [15]. It may also indicate the mode of transmission and help to relate the timing of key events (such as possible exposures and control measures) to the onset of symptoms.

Step 7: Calculate an incubation period

The incubation period is the interval between exposure to the disease agent and appearance of initial symptoms of the illness. While each disease has a characteristic incubation period, the incubation period for the disease will vary among individuals, due to physiological variations, differences in the degree of exposure to the disease agent and biological factors that influence susceptibility.

The incubation period has two main uses when investigating disease outbreaks [13]. If the exposure time is known, calculation of the incubation period can help to narrow the range of possible disease agents and will therefore direct subsequent laboratory tests and control measures.

Environmental investigation

The easiest way to conceptualise the environmental investigation is that it follows the principles of risk management. A risk management framework is a structured approach that can identify and manage risks in the environment to prevent the occurrence of disease. Risk management approaches have been adapted to specific settings such as health impact assessment, food safety programmes [31] and occupational health [22]. An environmental investigation of a disease outbreak uses the systematic risk management approach to identify risks, but starts with the knowledge that disease has occurred and then works through the system to pinpoint where a systemic breakdown has occurred and risk management has failed. The major thrust of environmental investigation is risk assessment based on process, not on physical structure [23].

Table 1: The components of environmental investigation in different food- and water-borne Outbreaks (Hennessy *et al.*, 2015)

Outbreak type	Environmental investigation components
Common event outbreak, usually food- or water- borne	Site visit and inspection HACCP-based food safety assessment / public health risk Management plan-based water assessment Collection of food, water, environmental specimens Collection of clinical specimens, e.g., faecal specimens food Handlers Case finding
Dispersed outbreak, usually food- or water-borne	As for common event when potential sources identified Site visits (as required by circumstances) o Restaurants, cafes, takeaways, supermarkets, delicatessens, caterers, food processors/manufacturers/distributors o Hotels, hostels, camps, prisons o Rest homes, hospitals o Schools, early childcare facilities, meeting rooms o Workplaces, farms o Water treatment stations: Review records, turbidity, chlorination (free available chlorine (FAC)), microbiological testing, catchment site visit, water samples
Outbreak type	**Environmental investigation components**
Institutional outbreak	Site visits and inspections Environmental risk assessment HACCP-based food safety assessment, if appropriate Collection of environmental specimens Case finding
Common site outbreak	Waterborne Visit implicated swimming pools: Review records of use, faecal accidents, chlorination (FAC), staff illness, protocols Legionellosis Visit potential sources and review level of human exposure and precautions in place
Community-wide, person- to person Outbreaks	Environmental specimens not usually required
Outbreak caused by unknown, but potentially serious disease causing agent	Environmental specimens and investigation depend on disease and suspected source

Laboratory Investigation

Laboratory techniques for identifying and quantifying organisms and toxins have always had an important role in disease outbreak investigation, mainly for identifying or confirming links between suspected contaminated substances and human illness [25]. Laboratory data are often instrumental in identifying outbreaks. Recent developments in laboratory techniques mean that laboratory sciences can greatly improve the sensitivity of outbreak detection by identifying clusters of cases with a common source. Previously, these clusters would have appeared sporadic and unconnected. Such findings may help strengthen links between outbreaks and their sources [26].

Outbreak control measures, communications and documentation

Outbreak Control Measures

Although definitive measures usually require knowledge of the source and reasons for the outbreak, control activities should be considered at all stages of the investigation [28]. Initial control measures will be based on knowledge of the pathogen, and probable sources and modes of transmission [29]. The sources of an outbreak can usually be considered as a continuum from 'upstream' determinants to 'downstream' factors. For example, an outbreak of meningococcal disease in a community could be simultaneously due to social and economic conditions predisposing people to over-crowding and poor housing, a lack of availability of accessible primary health care services for early diagnosis, and to close physical contact with an individual carrying nasopharyngeal *Neisseria meningitides* [9].

Examples of control measures aimed at the outbreak source

Outbreaks associated with food, water or environmental sources

- Closure of premises or site of outbreak (e.g., food premises closure)
- Modification of procedures (e.g., swimming pool filtration)
- Cleaning or disinfecting contaminated equipment or fittings (e.g., cooling towers).

Outbreaks associated with animal contact

- Removal from contact, treatment, isolation, immunisation or destruction of animal reservoirs (e.g., immunisation of cattle to prevent human leptospirosis).

Outbreaks associated with human sources

- Treatment of cases and carriers (e.g., treatment of individuals with tuberculosis disease or infection)
- Exclusion or restriction of activities (e.g., temporary restrictions placed on food handlers or health care workers with gastroenteritis symptoms)
- Isolation (e.g., use of universal precautions to manage hospital in patients infected with or carrying MRSA)
- Quarantine (e.g., people arriving in the country with viral haemorrhagic fever, close contacts of a confirmed case of measles)
- Education (e.g., advising individuals with STIs to use condoms during sexual contact).

Examples of control measures aimed at contaminated vehicles and vectors

Outbreaks associated with contaminated food or water

- Removal or recall of contaminated product (e.g., packaged food contaminated with Listeria)
- Treatment, pasteurisation or sterilisation of contaminated material (e.g., use of boiled or treated water).

Outbreaks associated with vectors

- Application of insecticides, setting traps, eliminating breeding habitats, improving management of solid waste (e.g., application of insecticide to breeding areas to control mosquito vectors) [22].

Examples of control measures aimed at susceptible humans

Outbreaks associated with food, water or environmental sources

- Education to change behaviour associated with food preparation or hygiene (e.g., education to improve food safety, implementation of a food safety plan)
- Instructions to treat or sterilise contaminated material (e.g., issuing 'boil water' notices)
- Education to reduce contact with vectors (e.g., use of screens, bed nets, long-sleeved shirts and insect repellents to reduce risk of vector borne disease).

Outbreaks associated with human sources

- ✓ Administration of chemoprophylaxis (e.g., isoniazid for tuberculosis)
- ✓ Administration of active and passive vaccines (e.g., immune globulin and vaccine for hepatitis A)
- ✓ Advice on physical barriers (e.g., use of condoms to prevent STIs)
- ✓ General improvement in host resistance (e.g., correct malnutrition or vitamin deficiency to reduce the effects of measles).

Communication during outbreak investigation

A coordinated approach to communication is an essential part of outbreak investigation activities. By their very nature, disease outbreaks occur at unexpected times, can grow rapidly in scale and attract considerable attention from the media, public and government agencies [31]. A planned approach to communication will help the outbreak team to remain focused on the investigation, safe in the knowledge that information circulating about the outbreak is accurate and that relationships with other agencies are being maintained [23].

It has become increasingly important that staff involved in outbreak control have risk communication training. Appreciating the role of social media in risk communication is vital. In major outbreak situations and emergencies local leaders are called upon to master both the news conference and the social media to build public cooperation and support for preparedness, response, and recovery measures [24].

The art of communicating risk to the public does not always come naturally, with many having to master it by following precise instructions to get the desired outcome. Risk communication is a tool for closing the gap between laypeople and experts, and helping stakeholders make more informed choices [9]. Risk communicators must learn to function under nearly impossible time constraints, while accepting the imperfect nature of their decisions. Using available information and the necessary expertise, action must be taken usually with some urgency while making the community understand and accept the inherent lack of certainty.

Risk issues involve both the physical hazard and the public's reaction to it. In some instances, a high level of public concern can be a greater danger than the hazard itself (e.g., immunisations, industrial chemicals and nuclear power) [26]. The opposite is true for situations such as indoor air pollution, food poisoning and obesity where a low level of public concern can present significant health risks. Wrongly perceived risk can create hazards by generating opposition to the adoption of risk management regulations and procedures e.g., accepting quarantine measures [30].

In summary, the following communication strategies and methods need to be put into consideration in an outbreak investigation;

1. Communication within the outbreak team
2. Communication with the Ministry of Health, the Ministry for Primary Industries, ESR, other key government agencies
3. Communication with the public, either directly or through the media
4. Communication with other agencies involved in the outbreak, such as local authorities, industry groups, local hospitals and local primary health care organisations.

Documentation

According to Simmons *et al.*, [11]. High quality, comprehensive documentation of all recognised outbreaks is essential for any disease surveillance system because:

1. National collection of outbreak data facilitates the recognition of relationships between events occurring in different areas of the country, such as the identification of widely dispersed outbreaks
2. The reports can be used to convince health professionals and the public of the need for preventive measures
3. Documentation of outbreaks may be used to evaluate and improve prevention strategies
4. It is rarely, if ever, possible to identify risk factors for disease from single, sporadic cases. Almost all risk factors are identified from investigations of outbreaks or groups of cases
5. Understanding of emerging diseases may be improved, especially modes of transmission and risk factors
6. Reports can be used as teaching aids for diseases and outbreak investigation, including identifying how future outbreak investigations may be improved
7. Outbreak investigations are generally improved through the discipline of systematic and comprehensive documentation
8. Local and national statistics on outbreak occurrence can more readily be compiled when a uniform approach to their recording is used.
9. It may be necessary for the fulfilment of international reporting requirements, especially if the disease is one where eradication is expected.

Routine outbreak documentation is categorized into two levels: Level one documentation which is the outbreak report form; and level two documentation which is the

outbreak investigation report.

Conclusion

This report presents a unified framework for outbreak management which can be put to use globally. This write-up builds substantially on previous sets of guidelines by adding sections on environmental and laboratory aspects of outbreak investigation to the section on epidemiology, and by describing outbreak management (control, communication and documentation). As such, the document encompasses the entire range of outbreak response activities.

The guidelines here also shows that the interrelationships between the different components of outbreak management do not necessarily occur in a linear and progressive sequence. Outbreak management must be adapted to the circumstances of each outbreak as it emerges. It is important to adopt a flexible approach to outbreak management. Nothing is ever perfect. More research on the field of environmental microbial monitoring, surveillance and disease outbreak is expected over time to further prepare individuals across the globe and educate key health workers in monitoring and containing future outbreaks.

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