UNIT 9 EARLY WARNING, ALERT, AND RESPONSE SYSTEM: APPLICATION OF BIG DATA AND ARTIFICIAL INTELLIGENCE*

Structure

9.0 OBJECTIVES

After studying this unit, you should be able to:

- Discuss the significance and role of Early Warning, Alert, and Response Systems (EWAR) in emergencies;
- Highlight the preparedness for implementation of EWAR;
- Evaluate the capacity levels of EWAR within a context;
- Assess the surveillance priorities;
- Explain the core functions of EWAR;
- Distinguish between the indicator-based and event-based Surveillance for EWAR;
- Discuss the application of EWAR during emergencies to oversee signals, events, and alerts; and

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- Examine the role of Big Data and Artificial Intelligence in bolstering public health systems.

9.1 INTRODUCTION

"Early Warning, Alert, and Response System is a system that provides an early warning of acute public health events and then connects this function to an immediate public health response. It is oneof the most immediate and important functions of a surveillance system" (WHO, 2022). It includesthe following components and processes.

- Early warning–the prompt identification of indicators indicating potential acute public health incidents. Early warning data sources may encompass reports from healthcare facilities, community members, and various entities, which contributes to both Indicator-based Surveillance (IBS).
- Event-based surveillance (EBS) systems.
- Alert management – the systematic procedures of handling all incoming information, from verifying signalsto assessing and characterisation the risk, todetermine whether the response is necessary to mitigate the public health risk. To ensure efficiency, it is recommended to direct all signals into a common system, enabling systematic investigation and management.
- Response – Public health measures are initiated upon the detection of an alert.

In this Unit, we will explain theneed and importance of Early Warning, Alert, and Response Systems in emergencies. It will contribute topreparing us and stakeholders for effective implementation, evaluating their capacity levels, conducting rapid assessments to identify surveillance priorities, and recognising their core functions. This discussion willhelp us to understand how they supervise signals, events, and alerts. It will also emphasise how to start an outbreak investigation, detect passive and active cases, and provide surveillance data to guide and monitor outbreak control tactics. We will also explore and explain, how Artificial Intelligence and Big Data revolutionise the public health system.

9.2 ROLE OF EARLY WARNING, ALERT, AND RESPONSE SYSTEMS IN EMERGENCIES

Emergencies create risk factors that contribute to the spread of communicable diseases. Thesefactors include food insecurity winding livelihoods, disruptions or failures in preventive or curative healthcare services (such as access to safe water and sanitation), mass displacement of individuals into crowded or camp-like settings or neighbouring host communities, which heighten the risk of overcrowding, sudden loss of livelihoods, and rapid environmental changes because of natural hazards. Emergencies can cause national surveillance systems to underperform, experience disruption, or not be in place at all, which may delay the detection and response to outbreaks (WHO)

Outbreaks can occur due to these factors, leading to increased morbidity and mortality among emergency-affected populations.Setting up an efficient early warning and response system is crucial during an emergency. The system needs to be able to quickly detect and react to events that could cause outbreaks and other health emergencies.

The overall aimof an early warning, alert, and response system duringan emergency is to minimise excess morbidity and mortality resulting from prioritisedepidemic-prone diseases and other public health hazards, including:

- Diseases with high case fatality ratios and potential for transmission include meningococcal meningitis, cholera, and measles;
- Communicable diseases that are newly appearing or reappearing, such as zoonotic diseases;
- Diseases identified for elimination or eradication (e.g., poliomyelitis); and
- Potential deliberate release hazards and diseases include chemical poisoning, anthrax, and tularemia.

9.3 PREPAREDNESS FOR EARLY WARNING, ALERT, AND RESPONSE SYSTEMS

Preparation is a vital part of the emergency cycle and extends to implementing Early Warning, Alert, and Response Systems.Tominimise the effects of outbreaks and health crises, nations need to enhance their ability to carry out the full spectrum of public health emergency prevention, preparedness, response, and recovery. This involves strengthening and reinforcing the capabilities of Early Warning, Alert, and Response Systems at each stage.

It is of utmost importance to proactively identify and enhance the human resources, material resources, and coordination required for Early Warning, Alert, and Response Systems to ensure their effectiveness. By identifying and improving the necessary human resources, material resources, and coordination for Early Warning, Alert, and Response Systems, we can easily deploy and expand these components as needed. It is crucial to work with local stakeholders to select EWAR tools that are tailored to their specific needs and circumstances. We must acquire the skills to utilise and implement these tools. It’s crucial to consistently update, maintain, and test these tools for continued preparedness in health emergencies. These measures will significantly reduce the time and effort required. Following a rapid assessment at the beginning of an emergency, the team of EWAR can focus on improving existing components' efficiency and expanding the surveillance network to encompass areas and populations that were previously neglected or displaced.

9.4 LEVELS OF EARLY WARNING, ALERT, AND RESPONSE CAPACITY WITHIN A SPECIFIC CONTEXT

The ability to consistently carry out EWAR activities or respond to emergencies is shaped by the local context. However, preparedness extends beyond EWAR alone. Furthermore, it heavily relies on the structure of both local and national surveillance systems. In situations such as conflicts or natural disasters, the health systems and surveillance structures may be significantly impacted or disrupted, requiring the creation and implementation of new response plans and systems.

i) ***Low Capacity***: In case of low capacity, such as in acute conflicts like the Syria crisis, sudden natural disasters like Tropical Cyclone Idai in Mozambique, or the rapid establishment of new displacement camps during the north-eastern Nigeria crisis, there is a high likelihood that surveillance systems and healthcare infrastructure, which rely on them, may experience substantial disruption or destruction. Occasionally, the national health authority may not have control over this infrastructure, increasing the risk of inadequate preparedness. Hence, it is wise to consider developing a new EWAR system as part of the assessment in similar situations.

ii) ***Moderate Capacity***: In situations of prolonged crises with notable outbreaks among affected communities, such as the cholera outbreaks in Yemen, and disaster-prone nations like Pakistan experiencing frequent flooding, there might exist a moderate level of Early Warning, Alert, and Response (EWAR) capacity.Nevertheless, the surveillance systems in these regions often face an ongoing lack of investment.We anticipate that certain core functions can lay the groundwork for improving regular EWAR operations. In the early stages of an emergency, authorities may consider using these systems or developing new EWAR systems, depending on the findings of assessments.

iii) ***High Capacity:*** In certain scenarios, the majority of essential EWAR functions may already exist, indicating high capacity. Given the circumstances, our focus should be on enhancing early warning capabilities through improving existing systems, as well as exploring their potential for emergency preparedness. Nevertheless, additional tools may be used to support the current capacity.As an example, in Fiji during Tropical Cyclone Winston, they strengthened the current sentinel surveillance system by implementing EWARS-in-a-box to improve logistics and communication between healthcare facilities.

Check Your Progress 1

Note: i) Use the space given below for your answers.

ii) Check your answer with those given at the end of the Unit.

1) Describe the role of early warning, alert, and response systems in emergencies.

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2) 'Preparation is a vital part of the emergency cycle and extends to implementing Early Warning, Alert, and Response Systems'. Elaborate.

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9.5 RAPID ASSESSMENT OF SURVEILLANCE PRIORITIES

A thorough assessment is required before implementing an EWAR system to create effective recommendations for designing a system suitable for a particular emergency and environment. The rapid assessment was led by the national public health authorities, with assistance from the WHO and other partners, as needed. The objective is to create recommendations that can be implemented by national public health authorities to establish a suitable EWAR system.

Essential stages in quick evaluations include determining critical illnesses, monitoring geographic extent, assessing surveillance capacity, and identifying urgent logistical and resource needs.If the evaluations and strategies for EWAR are complete, rapid assessments should take into account these findings and plans, expanding to consider the consequences of the specific emergency as well as potential new areas and affected populations. The essential stages of quickly assessing surveillance priorities are:

- Establish the regions and communities to be included in surveillance efforts,
- Define a timeframe and geographic boundaries for the swift evaluation,
- Recognise and assess crucial information sources, and establish a mechanism for community engagement,
- Identify the most critical epidemic-prone diseases, conditions, and environmental risks through risk assessment,
- Validate the existing capabilities for surveillance and response, and
- Develop practical recommendations tailored for implementation.

9.6 CORE FUNCTIONS FOR EARLY WARNING, ALERT, AND RESPONSE

EWAR serves as an early alert system for public health incidents, bridging this function with an immediate public health reaction. The diagramme below, (figure 9.1) illustrates the framework of EWAR functions during emergencies and their interconnectedness.

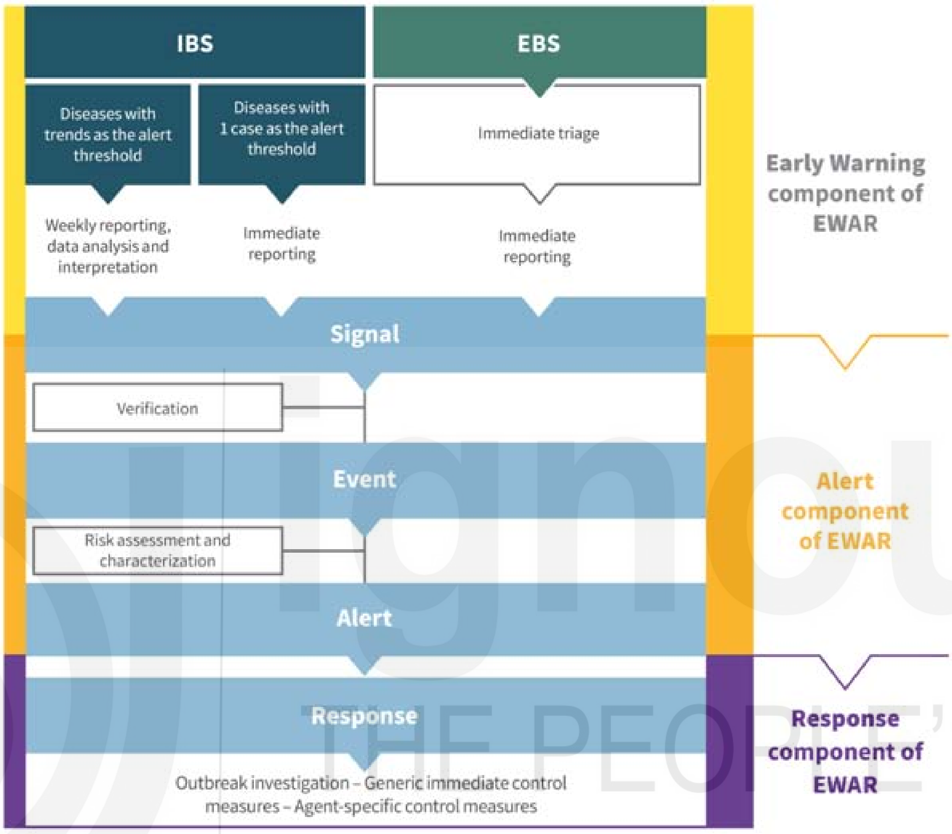

Figure 9.1: Components of EWAR

Source: WHO 2022

i) ***Alert***

The process of managing various information inputs, starting from signal verification to assessing and defining the risk, to determine if any action is necessary to mitigate public health hazards, is referred to as alert management. It is crucial to follow a consistent workflow for handling all signals, regardless of their origin, such as

- Signal → Verification → Discard, monitor or verify as event
- Event → Risk assessment and characterisation → Discard, monitor orconfirm as alert
- Alert → Response.

Verification, risk assessment, and risk characterisation are the essential steps in the alert management workflow.

ii) ***Response***

The response involves implementing any public health measures based on the risk evaluation of events. This guidance emphasises the following actions to bolster surveillance through EWAR as part of a public health response:

- Initiating an investigation into outbreaks and implementing early response measures
- Assisting in both passive and active case detection efforts
- Supplying surveillance data to steer and oversee outbreak management and control measures.

iii) ***Early Warning***

The EWAR system's primary component is Early Warning, which comprises two signal detection systems: IBS and EBS. These systems detect signals that require further investigation and contribute to the early warning function of surveillance systems. Although distinctions between the two may be important in some situations, combining IBS and EBS into a single system for early warning is possible, as shown by the similarities in case and event definitions.

9.7 INDICATOR-BASED SURVEILLANCE FOR EARLY WARNING, ALERT, AND RESPONSE

Indicator-based surveillance is the methodical gathering, monitoring, analysis, and interpretation of structured data (indicators) provided by health facilities or other reliable sources (such as Community Health Workers (CHW) and Community Health Volunteers (CHVs). Regardless of where the reporting comes from, it is always based on case definitions of priority illnesses or conditions. Working with EBS, IBS is a fundamental element of Early Warning systems for identifying public health hazards (Fig. below).

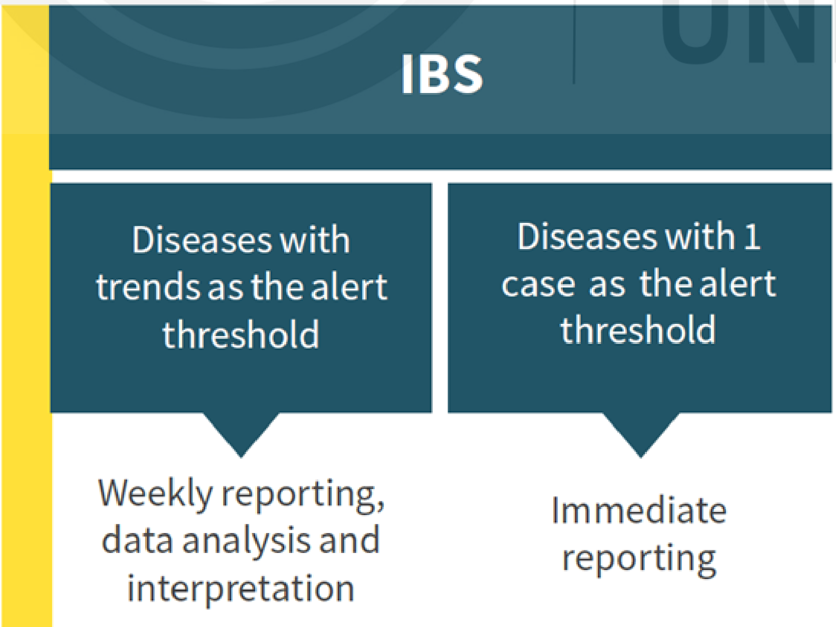

Figure 9.2: IBS

Source: Function of the Early Warning Component (WHO, 2022)

i) ***Principles of IBS Implementation as part of EWAR in Emergencies***

The implementation principles for IBS as part of EWAR in emergencies involve focusing on a narrow range of 8 to 12 priority diseases, considering the country's disease profile and context, and emphasising those posing significant risks of severe illness, death, or epidemic potential. Tailoring reporting frequencies, either weekly or immediate, based on assigned risk levels helps prevent system overload. Maintaining simplicity and flexibility for adaptability to evolving contexts is crucial. Local-level data analysis is preferred, and when not workable, involving stakeholders close to the field ensures context-specific conclusions and timely actions. Establishing multidirectional feedback loops among stakeholders throughout the data collection, analysis, and response processes promotes effective response understanding. We emphasise community engagement to foster confidence in healthcare and surveillance systems, particularly in IBS applications for Early Warning, Alert, and Response during emergencies.

ii) ***Strategy for IBS***

In developing an IBS strategy, it is necessary to provide a detailed account of each component of the system. This involves specifying in table 9.1 which diseases and conditions should be reported by whom, how often, and where.

Table 9.1: Questions and Factors to Consider when Deciding on the Strategy for IBS

Questions	Factors to Consider
Who should report?	IBS sources and reporting sites
What should be reported?	Priority diseases and conditions, case definitions and standards for reporting
When should it be reported?	Frequency of reporting for each disease/condition
Where should the reports go?	Information flow for disease reporting and responsibilities to take action based on the reports
How should it be reported?	Mechanisms for reporting and standard formats

iii) ***Source for IBS Data***

A usual source for IBS data is a predetermined network of health facilities (e.g., health posts, healthcentres, hospitals). Ideally, included health facility sites should:

- be located as close as possible to the affected populations;
- have good coverage of the affected populations, including specifically vulnerable populations;
- have sufficient personnel, equipment, and reliable telecommunications for routine reporting; and

- include all governmental, private, NGO, faith-based and other facilities in the affected area.

9.8 EVENT-BASED SURVEILLANCE FOR EARLY WARNING, ALERT, AND RESPONSE

EBS refers to the systematic gathering, monitoring, evaluation, and analysis of mostly unstructured and spontaneous information about potential public health hazards that pose an immediate threat to human health. Healthcare facilities, communities, or other stakeholders may report such information. EBS does not rely on case definitions, making it capable of detecting potential health hazards more rapidly and extending beyond healthcare facilities. It can detect diseases that are not explicitly covered in an organisation's IBS system.

The Early Warning system for public health hazards relies on the combined efforts of EBS and IBS to identify potential public health events. EBS has the advantage of being quickly implemented during emergencies, whereas establishing IBS may take longer. In the early stages of an emergency, the Integrated Biological Surveillance (IBS) system may be incomplete or not fully operational. A practical and valuable approach is to start Early Warning and Response (EWAR) surveillance by initiating Event-Based Surveillance (EBS) reporting from healthcare facilities and essential community representatives. This allows us to expand other surveillance activities as the situation evolves.

Principles of EBS

The Principles of EBS implementation as part of EWAR in emergencies are:

- Complement the IBS system and draw on the existing reporting structure and resources of IBS.
- Ensure systems are geared toward rapidly detecting public health hazards, including diseases and conditions not included in IBS.
- Implement the EBS system as quickly as possible–a simple reporting mechanism (e.g., a hotline in all health facilities and key community locations) can be highly effective for rapidly detecting outbreaks whileother EBS and IBS activities are scaled up.
- Align with and draw upon existing networks and reporting lines as muchas possible (e.g., health facilities, community networks, community health workers, teachers' unions).
- Adapt event definitions to the local context and expertise of the reporting sites.
- Establish standard workflows to immediately triage information generated by EBS, and to immediately report and manage signals.

When determining the approach for EBS, several questions and factors should be taken into account, which is represented in the following table.

Table 9.2: Questions and Factors to Consider when Deciding on the Strategy for EBS

Questions to Consider	Factors to Consider
Who should report?	EBS sources and reporting sites
What should be reported?	Event definitions
When should it be reported?	Frequency of reporting
Where should the reports go?	Information flow for event reporting and who is responsible foractions based on the reports
How should itbe reported?	Mechanisms for reporting and standard formats
What feedback mechanisms should be installed?	Communication and feedback loops between all levels of the EWAR system

9.9 MANAGEMENT OF SIGNALS, EVENTS, AND ALERTS

The EWAR system's ALERT function includes the management of signals, events, and alerts, which necessitates a well-defined procedure of detection, verification, risk assessment, and characterisation. Depending on the EWAR system and the sensitivity of signal detection, the volume of information, signals, and subsequent verification and risk assessment stages may vary significantly. Failing to invest in a well-structured alert management capability is a common mistake. Systems with insufficient capacity could not be able to distinguish between real signals and misleading signals, which might slow down or overload public health interventions and put staff members in danger of being overworked or demotivated causing them to miss incidents.

9.10 RESPONSE

Any public health action that is started because of an alert's risk assessment is referred to as a response. Response should be started as soon as feasible to stop the spread of the outbreak or public health emergency. This will help decrease illness and death rates andminimise the impact on healthcare services and the well-being of the affected community. The national public health authority (or equivalent) coordinates the investigation and reaction at the initial stages of an outbreak or public health emergency. The EWAR implementation team offers whatever help is required to direct the inquiry and answer.

When an alert is received regarding the agent and the population at risk, it may prompt immediate action. For example, a sharp increase in malaria cases may signal the need to assess the accessibility and utilisation of preventive measures like long-lasting insecticide-treated bed nets and mass administration of prophylactic medicines. In other situations, a public health investigation or outbreak response is necessary to identify the agent, source of illness, modes of transmission, and required interventions.

The goal is to detect cases within the community as early as possible during an outbreak or public health emergency. This facilitates easier case management, understanding of epidemiological dynamics, and reduction of transmission. Sometimes, the existing Indicator-Based Surveillance (IBS) at health facilities may not identify cases. Early Warning, Alert, and Response (EWAR) can assist in both passive and active case-finding, which involves systematically searching for cases in at-risk populations during outbreaks or public health emergencies. At a minimum, this includes daily collection of case lists from reporting sites.

National, disease-specific response plans and resources serve as the foundation of a complete response strategy that goes beyond EWAR. Importantly, general, or agent-specific control measures that are put in place in response to an alert or emergency should be viewed as temporary (time-limited) and based on a risk-based strategy with convincing scientific justification or proof. Communities ought to be at the centre of the decision-making process, knowledgeable about the facts, and taking part in the gathering and analysis of contextual information. We should also regularly assess the effectiveness of measures, as well as their potential negative effects on communities. We should regularly make adjustments under changing risks and based on the most recent scientific evidence. This process should continue until we identify an agent, at which point we can replace it with more targeted, agent-specific control measures.

i) ***Immediate and Generic Control Measures***

Immediate control measures are implemented upon identifying the suspected transmission route, even before confirming the agent, which may involve:

- Encouraging community involvement, seeking their input, and fostering awareness about health and hygiene.
- Reinforcing infection prevention and control (IPC) measures at healthcare facilities, including improving standard precautions and utilising additional personal protective equipment (PPE) such as masks and gloves.
- If there are suspicions of water or foodborne illnesses or environmental transmission, promptly collaborate with relevant authorities to investigate and sample potential sources of exposure. If necessary, take preventive actions such as treating household water in response to increased levels of faecal coliforms in drinking water sources.
- In the event of suspected zoonotic outbreaks, coordinate with the animal health sector to investigate the situation in animal populations and implement standard precautions.
- When there are suspicions of human-to-human transmission or the cause is unknown, implementing measures to minimise further transmission and facilitate early detection and monitoring of

potentially infected or exposed individuals. This includes temporarily isolating cases, tracing and following up with contacts, reducing interactions in high-risk settings, and screening individuals at control and entry points.

ii) ***Agent-specific Control Measures***

a) *Preventing Exposure*

To contain the source of infection and halt its spread within the community, various measures are taken, including:

- Swift diagnosis and treatment following standard protocols (e.g., cholera).
- Isolation and the use of protective barriers for patients (e.g., Viral Hemorrhagic Fever).
- Enhancing environmental and personal hygiene (e.g., shigellosis, cholera, hepatitis A, hepatitis E, typhoid).
- Managing vector or animal populations (e.g., dengue, Lassa fever, malaria, yellow fever).
- Proper disposal of sharp instruments (e.g., hepatitis B).
- Delivering health education tailored to the specific infectious agent and community needs.

b) *Preventing Infection*

Vulnerable populations are safeguarded through measures such as vaccination (e.g., cholera, diphtheria, measles, meningitis, yellow fever), access to clean water (e.g., shigellosis, cholera, hepatitis A, hepatitis E, typhoid), adequate shelter (e.g., Acute Respiratory Infections), and sanitation enhancements (e.g., cholera, hepatitis A, hepatitis E).

iii) ***Preventing Disease Post-Exposure***

At-risk groups receive chemoprophylaxis (e.g., malaria prophylaxis for pregnant women during outbreaks) and improved nutrition.

iv) ***Preventing Fatalities***

Swift diagnosis, effective case management, and accessible healthcare services are essential in preventing deaths.

9.11 BIG DATA AND ARTIFICIAL INTELLIGENCE

Big Data, characterised by its vast volume, velocity, and variety of information, offers a comprehensive and real-time understanding of disease patterns and potential outbreaks. By harnessing large datasets from diverse sources, such as social media, health records, and environmental sensors, the Early Warning, Alert, and Response System (EWARS) gain the capacity to swiftly detect emerging health threats. Artificial Intelligence (AI) complements this by employing sophisticated algorithms to analyse patterns, predict disease spread, and provide timely alerts. The integration of Big Data and AI enhances the system's ability to process and interpret complex information, enabling quicker and more accurate responses to potential epidemics or pandemics. This synergy between cutting-edge technologies establishes a proactive approach to public health, significantly improving our capacity to anticipate, monitor, and respond to health crises effectively.

In the realm of Big Data, the emphasis is on leveraging the enormous amounts of information generated in real-time. This allows for the swift detection of patterns, anomalies, and trends associated with potential health threats. The inherent ability of Big Data to process and analyse vast and varied datasets facilitates the identification of early indicators of emerging diseases, enabling timely intervention and response strategies. Moreover, Big Data analytics enables the tracking of population movements, monitoring of environmental factors, and assessment of healthcare utilisation patterns, contributing to a holistic understanding of public health scenarios. The integration of Big Data in the EWARS not only enhances the speed and accuracy of disease surveillance but also enables predictive modelling, offering insights into potential future outbreaks. By harnessing the power of Big Data, the public health system can move from a reactive stance to a proactive one, significantly improving our ability to anticipate, mitigate, and respond effectively to emerging health challenges.

AI, with its sophisticated algorithms and machine learning techniques, acts as a critical component within the Early Warning, Alert, and Response System (EWARS), enhancing the system's ability to process, analyse, and interpret the vast amounts of data generated in realtime. One key aspect of AI in public health is its predictive modelling capabilities. Through the continuous analysis of historical and real-time data, AI algorithms can identify patterns and trends associated with disease dynamics. This allows for the early detection of potential outbreaks, enabling timely intervention and response. AI's ability to adapt and learn from new data ensures that the system becomes more accurate and effective over time, refining its predictive capabilities.

Furthermore, AI plays a pivotal role in risk assessment and decision support. By evaluating multiple variables and considering complex relationships within data, AI algorithms can provide valuable insights into the likelihood and severity of potential health threats. This empowers public health authorities to make informed decisions, allocate resources efficiently, and implement targeted interventions.In the context of EWARS, AI also contributes to the automation of alert systems. By continuously monitoring and analysing data streams, AI can autonomously generate alerts when it detects unusual patterns or deviations from normal health conditions. This real-time alert mechanism enables a swift and proactive response, reducing the time lag between the identification of a potential threat and the implementation of preventive measures. The integration of Artificial Intelligence in the EWARS not only enhances the speed and accuracy of disease surveillance but also augments the system's overall intelligence, enabling a more proactive and adaptive approach to safeguard public health.

Check Your Progress 2

Note: i) Use the space given below for your answers.

ii) Check your answer with those given at the end of the Unit.

1) Describe core functions for early warning, alert and response.

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2) Discuss the role of EWAR in supporting the response.

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9.12 CONCLUSION

Now, the learners have gained the ability to understand the significance of Early Warning, Alert, and Response Systems (EWAR) in emergencies, prepare for EWAR implementation, evaluate EWAR capacity levels within a context, conduct swift assessments to identify surveillance priorities, recognise the core functions integral to early warning, alert, and response systems, comprehend the application of EWAR during emergencies to oversee signals, events, and alerts. In this Unit, we have explained the need and importance of EWAR in emergencies. It has contributed topreparing us and stakeholders for effective implementation, evaluating capacity levels, conducting rapid assessments to identify surveillance priorities, and recognising core functions. This discussion has helped us to understand how signals, events, and alerts are being supervised. It has also emphasised how to start an outbreak investigation, detect passive and active cases, and provide surveillance data to guide and monitor outbreak control tactics. We have also explored and explained, how Artificial Intelligence and Big Data revolutionise the public health system.

9.13 GLOSSARY

Artificial Intelligence : Artificial Intelligence (AI) is the branch of computer science that focuses on creating machines capable of performing tasks that typically require human intelligence. This includes activities such as learning, reasoning, problem-solving, perception, and language understanding. AI systems are designed to mimic cognitive functions and can be trained to execute complex operations, ranging from medical diagnosis to driving autonomous vehicles.

Response Capacity : It refers to the ability of an organisation, community, or society to respond to emergencies or crises effectively and rapidly. It encompasses the preparedness and readiness of human and material resources that enable a swift reaction to mitigate the impact of an event.

9.14 REFERENCES

WHO. (2023). *Early Warning Alert and Response (EWAR) in emergencies: An operational guide*. https://www.who.int/publications/i/item/9789240063587

WHO (2022). *Early Warning Alert and Response in Emergencies: An operational guide* ISBN 978-92-4-006358-7 https://apps.who.int/iris/rest/bitstreams/1489238/retrieve

9.15 ANSWERS TO CHECK YOUR PROGRESS EXERCISES

Check Your Progress 1

1) Your answer should include the following points:
   - For details, refer to Section 9.2
2) Your answer should include the following points:
   - For details, refer to Section 9.3

Check Your Progress 2

1) Your answer should include the following points:
   - For details, refer to Section 9.6
2) Your answer should include the following points:
   - For details, refer to Section 9.10