SINGAPORE PANDEMIC PREPAREDNESS AND RESPONSE FRAMEWORK

Communicable Diseases Agency
Singapore

Prepare · Prevent · Protect

Content

Section 1

The Context

Chapter 1: Introduction

1.1 A paradigm shift: Beyond a disease-specific to include a disease-agnostic approach

In today's interconnected world, with its densely populated urban areas and changing climate, infectious disease (ID) events are now more likely to occur. Recent ID events, with their profound impact on societies and economies, have underscored the critical need for a robust and adaptable approach to outbreak preparedness. Past outbreaks have exposed vulnerabilities in existing systems and highlighted the importance of preparedness and resilience. Learning from past experiences, Singapore is poised to enhance its readiness by building stronger, more agile systems that can protect communities and ensure resilience against any future ID threats.

Earlier preparedness approaches relied on disease-specific plans, tailored to combat known pathogens with particular characteristics (e.g. their mode of transmission, clinical severity, and transmissibility). However, when faced with new IDs, these disease-specific plans may not be sufficient. They can lead to delays in recognising unique challenges, adapting and modifying measures, and mobilising resources effectively. The need for a more flexible and integrated approach is clear – one that can swiftly incorporate the latest clinical evidence, and scientific and medical advancements as they arise.

Singapore is embracing a forward-thinking strategy that broadens from a disease-specific to include a disease-agnostic approach to address both known and unknown disease threats using an integrated preparedness and response framework. Known as the "Pandemic Preparedness and Response Framework", it emphasises the development of modular and adaptable systems and resources that can be quickly tailored and scaled to meet the evolving needs of various diseases. By unifying the capabilities and response mechanisms across the Singapore Government, this framework aims to enhance efficiency, optimise resource allocation, and integrate valuable insights from past events and key stakeholders.

This Pandemic Preparedness and Response Framework reflects Singapore's commitment to proactive planning, robust surveillance, and coordinated multi-agency responses. It also recognises the complex interplay between human, animal, vector, and the environment, further strengthening our nation's ability to stand resilient in the face of future public health challenges.

1.2 Objective of document

The primary objective of this document is to introduce an integrated preparedness and response framework for managing pandemics in Singapore. This framework will guide and inform our overall preparedness and response efforts, ensuring policies across different sectors are well-informed, coordinated, and aligned with the best practices in public health crisis management. Organisations can use the framework as a reference to develop their own tailored plans that address their specific functions and challenges, while contributing to broader public health outcomes.

This framework also emphasises the importance of clear public communications and working with the community across all activities. This will strengthen stakeholder collaboration, foster transparency, address misinformation and disinformation, and maintain public confidence and trust. This approach aims to create a well-informed public that can contribute to prevention efforts, comply with necessary measures, and support the overall response to IDs.

While the framework provides a flexible and integrated approach for managing pandemics in Singapore, its considerations and components are equally applicable to the management of IDs outbreaks, whether caused by known or novel pathogens. It provides a flexible approach that can be adapted to varying scenarios regardless of the speed or scale of transmission.

1.3 Overview of document

This document is divided into four sections. It provides an overview of five categories of public health and social measures (PHSM) and medical countermeasures that can be implemented in the event of a pandemic.

ⓐ **Section 1: The Context**

Provides an introduction to pandemics and highlights the need for a disease-agnostic and modular approach to pandemic preparedness planning.

ⓑ **Section 2: The Framework**

Provides an overview of the framework by defining the main public health outcomes and key considerations that will guide the choice and use of suitable PHSM and medical countermeasures for a pandemic.

ⓒ **Section 3: The Measures**

Presents a range of measures across five categories: (i) Detection, surveillance, and sense-making, (ii) Point of Entry (PoE) measures, (iii) Healthcare provision, (iv) Medical countermeasures, and (v) Population-based measures. These serve as modules that can be arranged into a pandemic plan, with various possible permutations depending on disease characteristics and outbreak context.

ⓓ **Section 4: The Enablers**

Presents the range of enablers, such as Whole of Government (WoG) coordination, communications, rallying the community, that make these measures possible.

1.4 Who should read this?

This pandemic preparedness and response framework is intended for:

ⓐ Stakeholders involved in outbreak prevention, preparedness, and response in Singapore, including
- Government agencies both within and beyond the health sector;
- Healthcare institutions and providers;
- Private sector and community partners, across all fields; and
- Research and academic communities.

ⓑ Members of the public interested in understanding Singapore's approach to disease outbreak preparedness and response.

1.5 Development process

This framework is developed based on lessons from previous disease outbreaks, including the COVID-19 pandemic, and draws on Singapore's experience in managing these public health challenges. Its development also incorporated insights from key stakeholders, including government agencies and public health and subject matter experts, through targeted workshops and structured focus group discussions. The framework and its considerations are aligned with that proposed by the World Health Organization (WHO). With advancements in science and technology, new measures may emerge, and the framework would need to be updated accordingly. For instance, during the COVID-19 pandemic, new digital tools (e.g. digital contact tracing using Bluetooth technology) were used to help track the virus spread, which were not available in past outbreaks. .

The framework is developed by the Communicable Diseases Agency (CDA), a statutory board under Singapore's Ministry of Health (MOH), working with a wide range of stakeholders from across all agencies and sectors. The CDA leads efforts to prevent, detect, prepare for, manage, and control IDs in Singapore.

Chapter 2: Pandemic preparedness

2.1 What are outbreaks, epidemics, and pandemics?

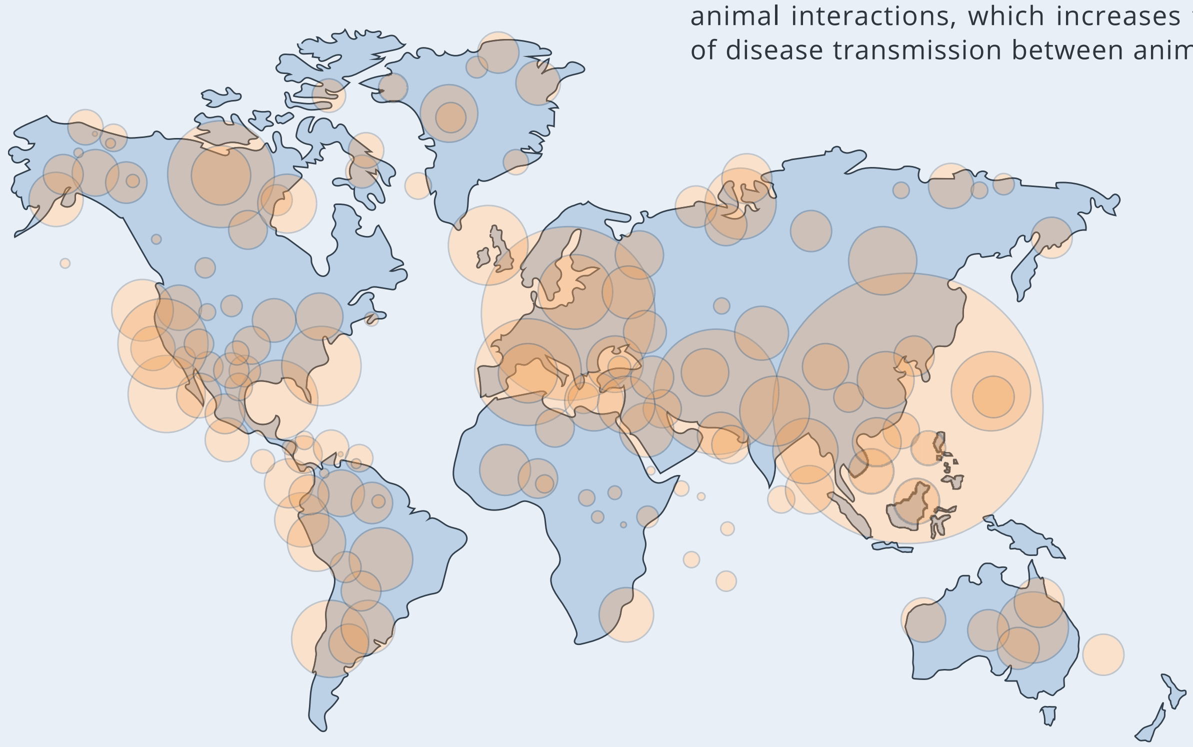
An **outbreak** is defined as a noticeable increase above the expected number of cases, while an **epidemic** refers to an unanticipated surge in the incidence of a disease within a defined geographic region. Outbreaks impact public health and have social and economic ramifications. These impacts may arise from the disease or measures implemented to prevent and control its spread.

A **pandemic** is when an ID spreads over large geographical areas and across international borders, affecting a significant portion of the world's population. The rapid progression of past incidents from outbreak to pandemic underscores the importance of pandemic preparedness, which involves broader planning for a health crisis that spans multiple regions or countries, to mitigate its impact.

2.2 How do IDs spread and become pandemics?

Pandemics can arise from both known and novel IDs. Of particular concern are novel IDs which may start from a mutation or recombination of known pathogens, resulting in a sufficiently distinct pathogen with outbreak potential. It may also be from zoonotic transmission, where a known or unknown pathogen with natural animal hosts mutates to infect humans. This novel pathogen may spread easily within a population if it acquires the ability to be transmitted between humans. Without effective containment to limit its spread within a specific area, the situation may evolve into an epidemic, then a pandemic.

The spread of an ID may be significantly influenced by broader environmental and sociocultural factors. Urbanisation, for instance, disrupts habitats and increases human-animal interactions, which increases the risk of disease transmission between animals and



humans. Globalisation has also increased the movement of people and goods across borders, which facilitates the movement of pathogens. Concurrently, climate change risks disrupt ecological balances, leading to more extreme weather events which can then favour the proliferation of disease-carrying vectors across broader geographical regions. Figure 1 shows the increasing frequency of outbreaks of diseases in Singapore and globally over the last three decades.

2.3 Why is Singapore vulnerable to pandemics?

Singapore is a highly urbanised and densely populated city-state, with an extensive public transportation network that connects communities across the country. This means that diseases can spread more easily in crowded places and from one part of the island to another. As of 2024, the population is 6.04 million. With an ageing population — by 2030, one in four Singaporeans will be aged 65 or above.

Singapore is an international travel and logistics hub with one of the busiest airports and seaports worldwide. In 2023, Singapore received over 58 million international air travellers and 140,000 annual vessel calls. It also has one of the world's busiest land borders with Malaysia, with up to 540,000 people, crossing daily for work, leisure, and trade. As such, Singapore is vulnerable to the importation and transmission of novel and emerging IDs. At the same time, because of its small and open economy that is dependent on trade, Singapore can be heavily impacted by international public health measures or travel and trade restrictions.

Being situated within Southeast Asia where there is rich biodiversity, vector and pathogen diversity, and human-wildlife-livestock interactions, Singapore is within the epicentre of potential emerging IDs and spillover events. The risk of importation and spread of IDs is further compounded by the prevalence of vector-borne diseases in the region, as well as climate factors that could facilitate their spread.

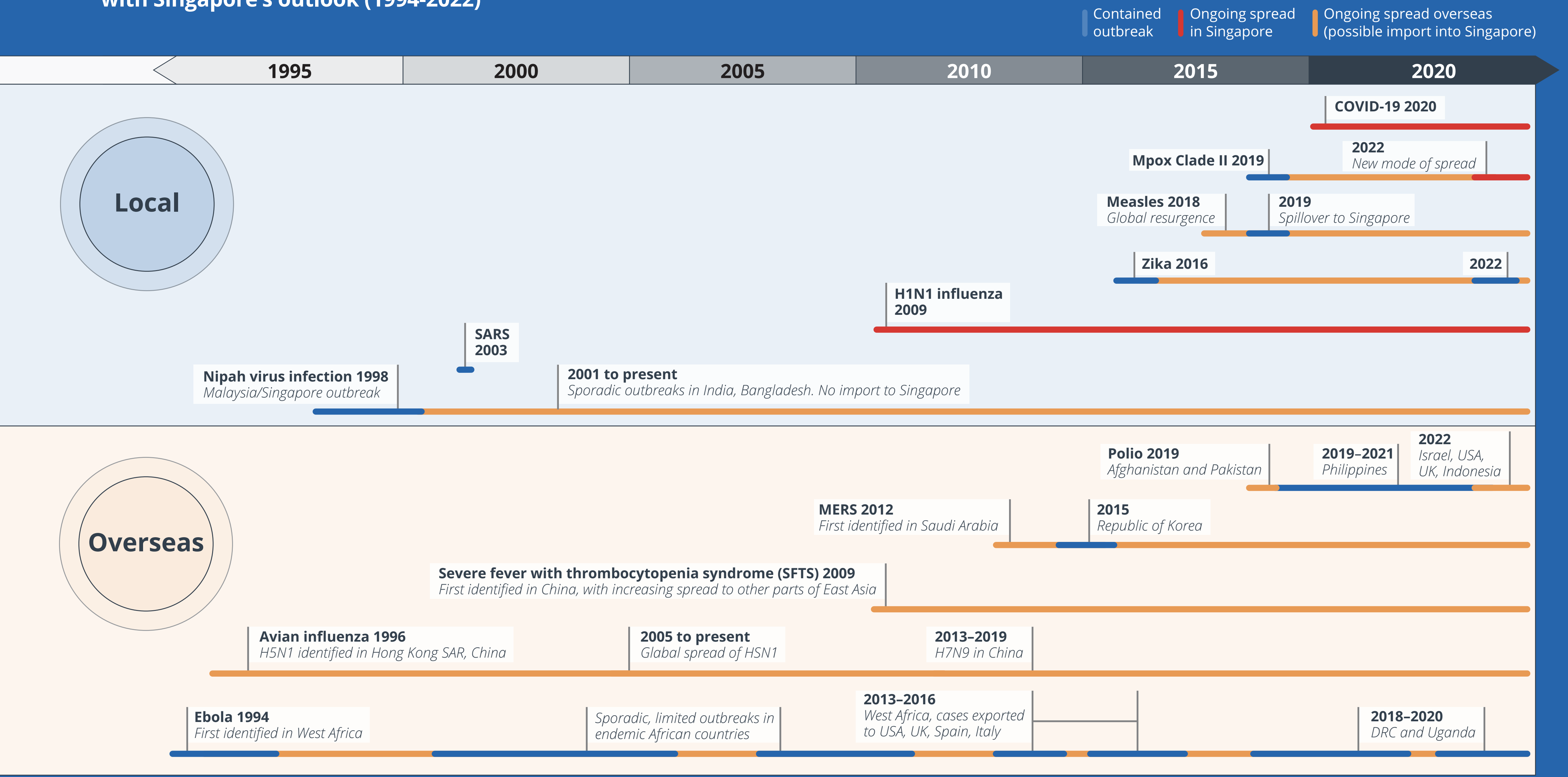
At the same time, Singapore has high standards of hygiene and medical care, including potable tap water, good sanitation and waste management, and widespread access to quality healthcare facilities. With these, disease outbreaks that are related to poor hygiene, such as those primarily spread through contaminated water sources and poor sanitation, or lack of healthcare access, tend to be less likely in Singapore.

2.4 Why pandemic preparedness matters?

Pandemics can strike with little warning — and when they do, can rapidly disrupt every aspect of life. From disrupted daily routines to overwhelmed healthcare systems, disrupted supply chains, businesses, and education, pandemics affect every part of society.

Pandemic preparedness is an ongoing effort and remains a crucial public health priority. This effort helps Singapore maintain critical functions and recover quickly from pandemics while minimising economic and social disruption.

Figure 1: Overview of key global and local disease outbreaks with Singapore's outlook (1994-2022)



SINGAPORE PANDEMIC PREPAREDNESS AND RESPONSE FRAMEWORK

Section 2

The Framework

Chapter 3: Defining the overall outcomes

The Pandemic Preparedness and Response Framework focuses on two overall outcomes — saving lives and protecting livelihoods. Effective preparedness and response strategies must prioritise measures that safeguard the health of the population while simultaneously consider social and economic stability. Together, these two goals ensure the wellbeing of individuals and the nation through balanced and comprehensive public health and social measures (PHSM) and medical countermeasures.

3.1 Saving lives

A priority is to ensure the safety and well-being of all Singapore residents, including the vulnerable. This involves reducing spread and preventing infections (primary prevention), early detection of cases (secondary prevention), and providing prompt and effective treatment (tertiary prevention).

3.2 Protecting livelihoods

Singapore must maintain its global connections and safeguard its economy. To achieve this, Singapore implements effective outbreak management strategies on both international and domestic fronts.

Internationally, Singapore focuses on balancing the need to reduce the risk of importation of cases with maintaining international relations, trade, and essential travel. This involves coordination with other countries and international partners through continuous dialogue and collaboration to harmonise policies, exchange information, and manage Point of Entry (PoE) measures in a way that allows the safe movement of people and goods.

Domestically, Singapore focuses on optimising measures to reduce the severity and duration of outbreaks within our national borders. Targeted strategies allow unaffected sectors and geographical areas to continue functioning where possible and minimise the extent and impact of these measures on the livelihoods of residents.

Chapter 4: Key considerations for the public health strategy

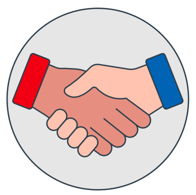
Having a set of key considerations is essential to guide the selection and contextualisation of appropriate measures when developing an effective, evidence-based public health strategy to address an infectious disease (ID). These key considerations should be regularly assessed as the situation evolves, ensuring the strategy remains current and actionable.

4.1 Epidemiological factors

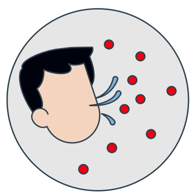
Understanding epidemiological factors ensure that selected measures are tailored to the specific characteristics of the disease. These factors influence the occurrence, spread, and control of diseases within a population, and include:

a Mode of transmission

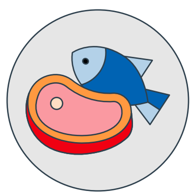
Transmission can occur through:



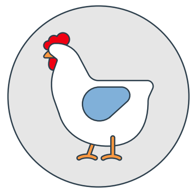
Contact, either directly with infected individuals (including through sexual interactions) or indirectly through contaminated surfaces or objects



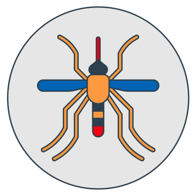
The air, where infectious respiratory particles transmit disease



Food and water



Zoonosis, where animal pathogens infect humans



Vectors, where insects or animals act as an intermediary between human hosts or between animals and humans

b Transmissibility

Transmissibility is determined by several factors including:

- How infective the pathogen is;
- How contagious an infected individual is;
- How susceptible new hosts are to infection;
- The nature and frequency of interactions between infected and susceptible individuals; and
- How well the pathogen survives in the environment during transmission.

Transmissibility is often measured by the basic reproduction number (R_0), an epidemiologic metric used to refer to the ability of a pathogen to spread from one host to another in the absence of interventions.

c Virulence

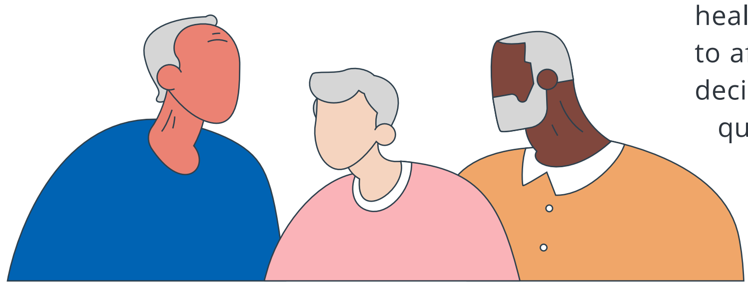
Virulence refers to the ability of a pathogen to cause disease, which is often measured using the case fatality rate (CFR) as a proxy. CFR describes the proportion of people who die from the disease out of the total number of people diagnosed with the disease over a certain period. Some diseases can cause chronic, debilitating outcomes that affect quality of life. Factors such as the pathogen's ability to colonise, evade a host's immune system and cause damage contribute to how harmful it can be.

d At-risk population

Some populations face higher risk of ID exposure than others due to their occupation or lifestyle. Frontline healthcare workers, laboratory workers who handle infected specimens, and those in crowded or unsanitary work environments may face heightened risks. Other high-risk groups include individuals engaging in high-risk behaviours, such as intravenous drug use or unprotected sex with multiple partners, those living in densely populated areas especially with poor ventilation or sanitation, and travellers frequenting disease outbreak or disease endemic regions. Identifying these populations is essential for targeted disease prevention and control strategies.

e Vulnerable population

Some populations are more susceptible to being infected due to characteristics such as age, gender, and health status. Children, particularly infants, are often susceptible due to their under-developed immune systems. The elderly face increased risks from age-related immune decline and comorbidities. Medically vulnerable individuals, such as those with chronic diseases or immunosuppression, have reduced capacity to fight infections. Pregnant women are at higher risk due to physiological changes and potential complications for both mother and foetus, including pathogens that can cross the placenta and affect foetal growth and development. These groups often experience more severe outcomes and require tailored prevention and treatment strategies.



4.2 Contextual factors

Contextual factors reflect the risk landscape and conditions in which the strategy takes place and can significantly affect its success. These include:

a Likelihood of disease importation

High travel volume and connectivity with source or affected countries contribute to high disease importation risk. This may necessitate stricter border controls, travel restrictions, and quarantine measures for incoming travellers. These measures, however, are generally temporary measures implemented to delay importation and reduce further introduction of cases into the community, allowing time to scale up domestic response capabilities. Accurate evaluation of importation risk helps optimise the balance between border control and domestic measures, for more effective management of the outbreak.

b Availability, sensitivity, and specificity of diagnostics

The availability, sensitivity, and specificity of diagnostics play a crucial role in shaping policy and public health strategies. Limited availability of tests, including insufficient stocks and delays in deployment, can hinder accurate case identification and contact tracing. This may lead to an underestimation of the scale of the outbreak and increase the risk of further spread by infectious individuals in the community. Likewise, low sensitivity may result in false negatives, allowing infected individuals to spread the disease unknowingly, while low specificity can lead to false positives, unnecessarily straining healthcare resources and causing undue stress to affected individuals. These factors influence decisions on case definitions, testing strategies, quarantine measures, and resource allocation.

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ⓒ Local outbreak situation

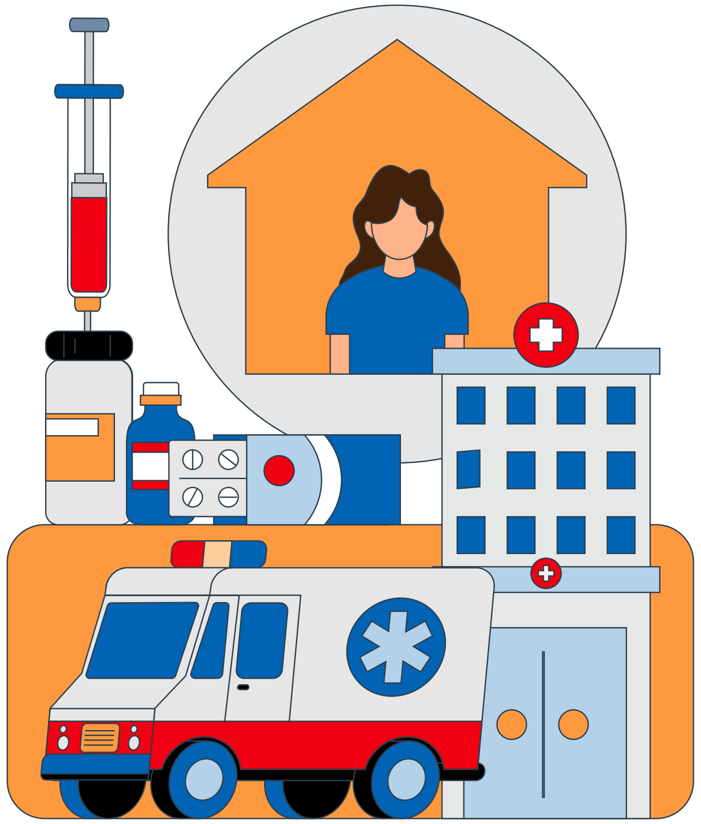
The extent of community spread, case numbers, and transmission patterns inform decisions on containment and mitigation measures, such as movement restrictions, physical distancing, and mask mandates. A robust and up-to-date understanding of local transmission patterns and the epidemiological situation helps in tailoring community measures, contact tracing efforts and vaccination strategies. Additionally, the disease's impact on different demographic groups can also guide targeted measures for at-risk and vulnerable populations.

ⓓ Availability of safe and effective therapeutics

Safe and effective therapeutics including antimicrobials (e.g. antibiotics, antivirals, antifungals, and antiparasitic drugs) and supportive therapies, can reduce disease severity, mortality rates, and burden on healthcare systems. Antimicrobial therapy targets and eliminates the underlying infection, while supportive therapy focuses on managing symptoms and maintaining vital functions to aid recovery. Additional antimicrobials may also be used to treat secondary infections among cases. Limited availability of therapeutics may necessitate prioritisation strategies that focus on at-risk and vulnerable populations.

ⓔ Availability of safe and effective vaccines

A safe, highly effective, and widely available vaccine enables more extensive immunisation strategies, potentially leading to earlier control of the disease. This includes reducing the risk of infection as well as the risk of developing severe disease and poorer outcomes. Vaccine effectiveness, including waning of protection over time, determines the level of population coverage required for herd immunity (where achievable). Concerns about vaccine side effects, whether mild or severe, can lead to hesitancy, reducing public acceptance and overall uptake, thereby impacting herd immunity efforts. In the initial stages when vaccine supply may be limited, prioritisation strategies are necessary to ensure that the most vulnerable and at-risk populations receive vaccination first, maximising the impact



of available doses. These factors collectively shape policies on vaccine mandates.

ⓕ Healthcare capacity and ability to cope with pandemic demand

The capacity of primary care, community care and hospitals, as well as the availability of intensive care units, medical equipment, and trained healthcare personnel directly influence the ability to manage severe cases and prevent mortality. Resource availability affects decisions on triage protocols, allocation of medical supplies, and deployment of temporary medical facilities. The healthcare system's resilience also impacts strategies for maintaining essential non-pandemic health services.

4.3 Scientific and implementation factors

Scientific and implementation factors contribute to the decision-making process by ensuring that the selected measures are pragmatic, reasonable, and in line with our overarching objectives:

SINGAPORE PANDEMIC PREPAREDNESS AND RESPONSE FRAMEWORK

ⓐ Evidence-based practices

Evidence-based practice draws upon the latest available data and information on disease characteristics, PHSM, and medical countermeasures. By combining this information with current disease surveillance data, decision-makers can determine the most appropriate interventions for the situation at hand. The robustness and quality of the evidence strengthen the confidence in implementing effective measures. Notably, during the emergence of a novel disease, the understanding of its characteristics and the effectiveness of interventions typically evolves as new evidence emerges.

ⓑ Adaptability

Adaptability enables flexible response as situations evolve and new information emerges. This includes regular refinements based on the latest epidemiological data and implementation of a dynamic, phased approach that is calibrated to the prevailing situation. Being able to make timely adjustments is essential when dealing with changing situations. When faced with uncertainty and incomplete information, implementing measures based on preliminary data helps stay ahead of disease transmission while our understanding of the pathogen develops. Early warning signals of potential risks warrant prompt preventive action to safeguard healthcare capacity, while maintaining a balanced approach informed by available evidence.

ⓒ Feasibility

Feasibility considers how practical and achievable a measure is within existing constraints and resources. This includes assessing the availability of manpower, equipment, infrastructure, and public health budget needed to execute the proposed measures effectively. The public acceptance and understanding, shaped by prevailing social norms and community values, directly impact implementation success as they influence community participation and adoption of the measures.

ⓓ Sustainability

Sustainability refers to the ability to maintain a measure's effectiveness over time without requiring excessive additional resources or support. It significantly influences the long-term success of a public health strategy, as it focuses on achieving lasting positive impacts on health indicators while accounting for the psychological, social, and economic effects across different segments of society.

4.4 Impact factors

ⓐ Proportionality

Proportionality means ensuring health measures match the actual level of risk. This involves choosing appropriate responses based on careful local assessments, ranging from basic precautionary measures to more comprehensive interventions where needed. Areas with different risk levels may need different approaches, based on local conditions. When measures are disproportionate to the actual threat level, they can unnecessarily affect daily life and the economy, potentially undermining the overall response strategy. In situations where multiple waves or variants emerge, a flexible and scalable approach allows for rapid adjustment of measures, ensuring an appropriate balance between public health protection and societal functions.

ⓑ Accessibility and coverage

Accessibility and coverage reflect how well a measure reaches and benefits its intended population groups. Identifying and addressing potential barriers improves health outcomes, particularly for vulnerable and at-risk individuals. When certain population groups are more likely to be infected or face more severe outcomes (e.g. elderly), tailored interventions may be needed to enhance the implementation and effectiveness of outbreak response measures.

SINGAPORE PANDEMIC PREPAREDNESS AND RESPONSE FRAMEWORK

Overview of Singapore's Approach to Pandemic Preparedness and Response

Saving Lives and Protecting Livelihoods

Key Considerations Used To Assess Risk and Guide Implementation

Epidemiological Factors

- Mode of transmission
- Transmissibility
- Virulence
- At-risk population
- Vulnerable population

Contextual Factors

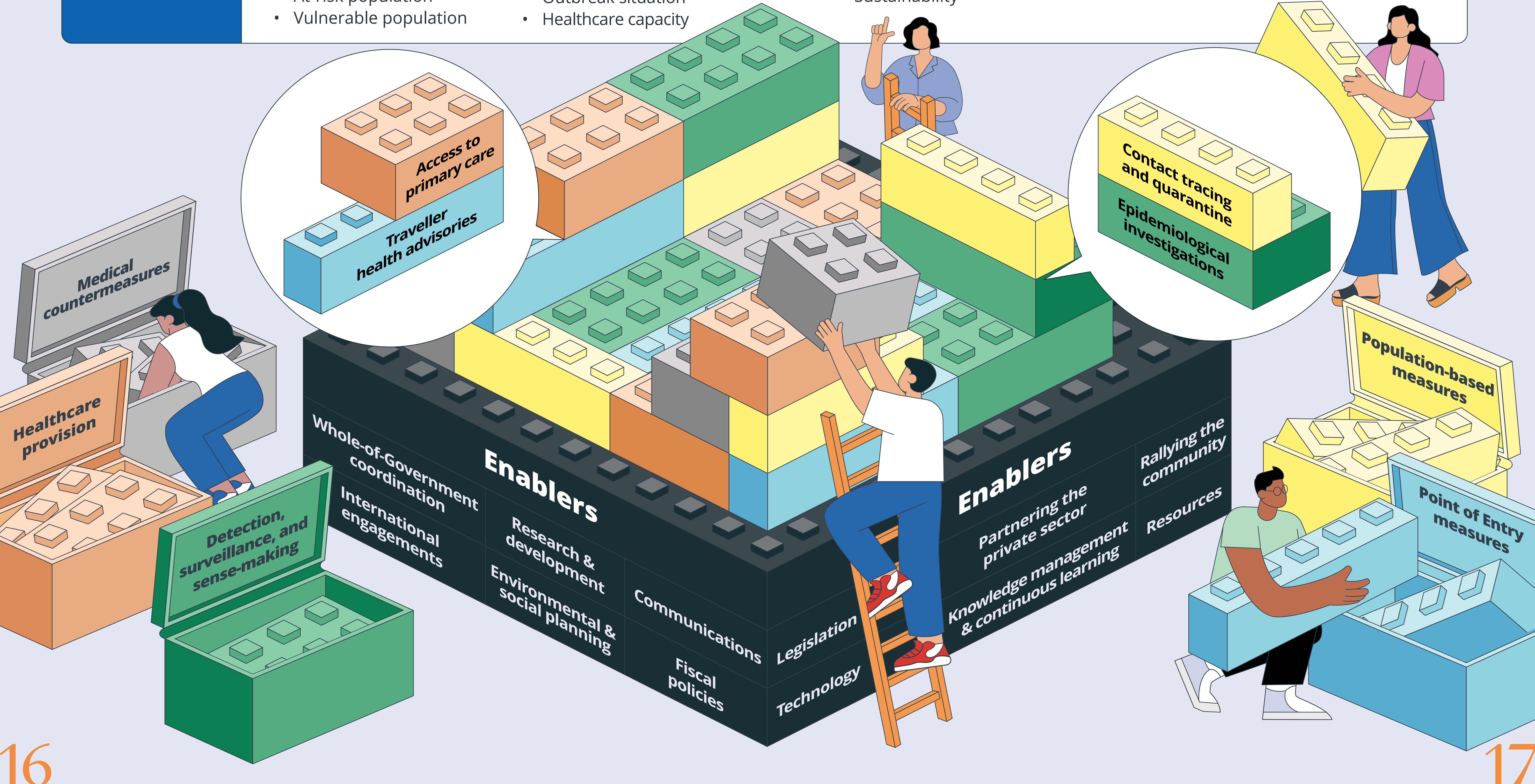
- Likelihood of importation
- Availability of medical countermeasures
- Outbreak situation
- Healthcare capacity

Scientific and Implementation Factors

- Evidence-based practices
- Adaptability
- Feasibility
- Sustainability

Impact Factors

- Proportionality
- Accessibility and coverage



The Measures

This framework encompasses measures across five key categories to manage disease outbreak. These responses can be calibrated based on the disease characteristics and prevailing risk level, ensuring a flexible and effective approach to disease control.

Detection, surveillance, and sense-making

- Horizon scanning and external surveillance
- Integrated local surveillance
- Epidemiological investigations
- Risk assessment
- Mathematical modelling
- Forward planning

Point of Entry measures

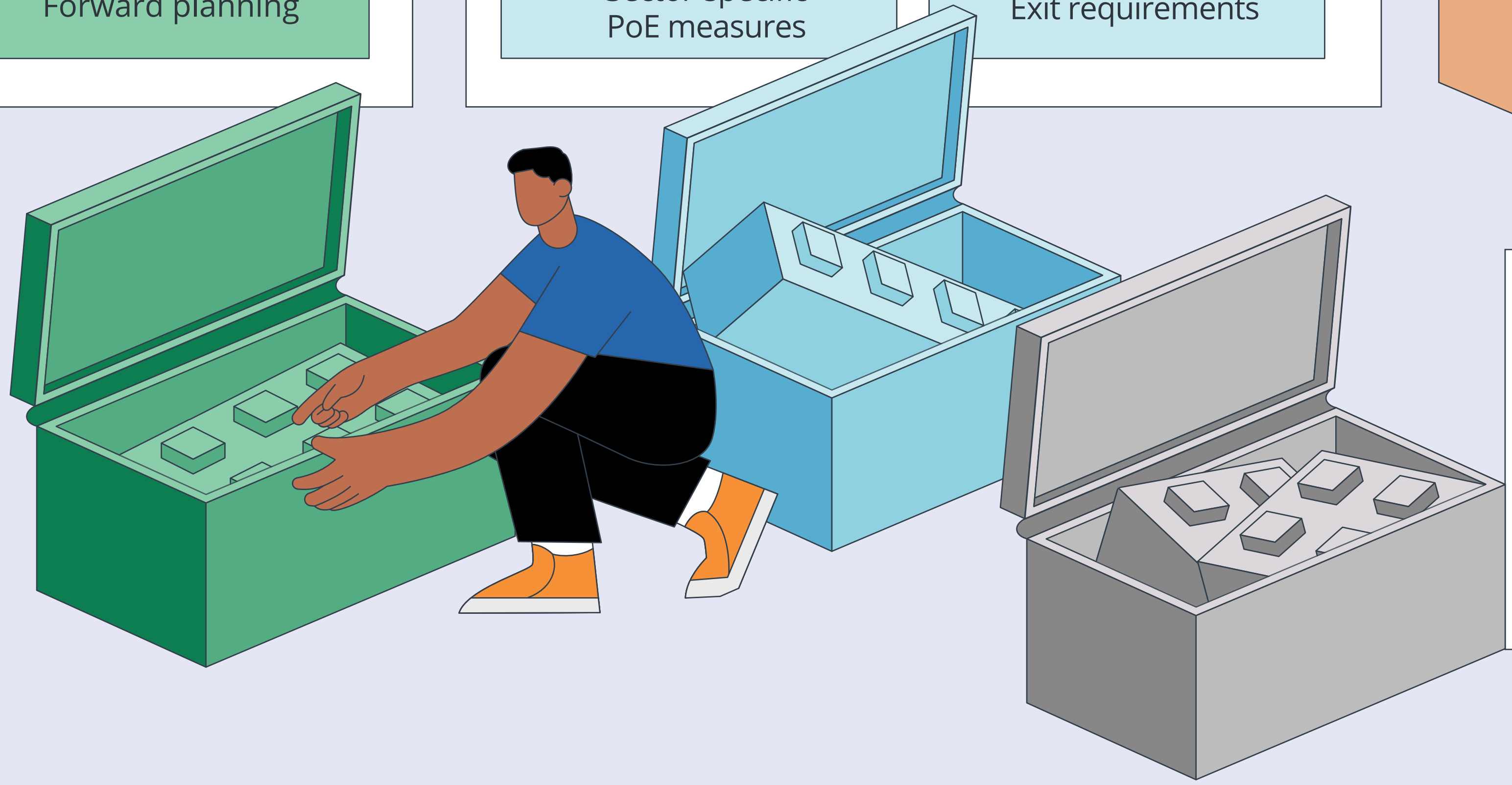
- Traveller health advisories
- In-flight/vessel/vehicle mask-wearing
- Vaccination-differentiated PoE measures
- Travel volume reduction
- Pre-departure test
- Symptom screening
- Health declaration and follow-up assessment
- On-arrival test
- Risk-based segregation
- On-arrival quarantine
- Disinsection, deratisation, disinfection, or decontamination of conveyances and goods
- Sector-specific PoE measures
- Exit requirements

Healthcare provision

- Access to primary care
- Health system resilience
- Prioritise and restructure care
- Infection prevention and control

Population-based measures

- Personal protection measures
- Safe distancing
- Capacity limits
- Workplace requirements
- Group size limits
- Physical separation barriers
- Isolation
- Contact tracing and quarantine
- Screening at venue entry points
- Vaccination-differentiated measures
- Cessation of services
- Lockdowns
- One Health control measures
- Sector-specific control measures



Medical countermeasures (e.g. vaccines and drugs)

- Research and development
- Regulatory approval and recommendations
- Deploy and implement medical countermeasures
- Supply chain management

Section 3

The Measures

Chapter 5: Detection, surveillance, and sense-making

This section describes the range of measures across five categories: (i) Detection, surveillance, and sense-making, (ii) Point of Entry (PoE) measures, (iii) Healthcare provision, (iv) Medical countermeasures, and (v) Population-based measures. The measures may be implemented in response to different pathogens, calibrated to the risk level and nature of the disease. Key considerations in the implementation of the measures are also touched on.

Detection, surveillance, and sense-making are essential for pandemic preparedness and response because they enable early identification, continuous monitoring, and informed decision-making to control infectious disease (ID) threats. Detection ensures that IDs are identified quickly, allowing for rapid response. Surveillance continuously tracks the spread, severity and patterns of IDs to monitor epidemiological characteristics of the threat, ensuring timely awareness of changes in transmission, virulence or affected populations. Sense-making integrates the information to guide the effective communication of risks and appropriate implementation of measures.

Surveillance methods

Surveillance methods encompass a wide range of ways to detect, identify, and monitor IDs, including both passive and active approaches. Passive surveillance involves the routine collection of data from existing systems, while active surveillance involves targeted searches and sampling. Collectively, these provide a comprehensive picture of disease activity, enabling early detection of outbreaks.

5.1 Horizon scanning and external surveillance

Horizon scanning is the process of screening and monitoring available information sources to detect signals, events, and threats of public health significance. It serves as an early warning system to kickstart risk assessment and risk management processes. Risk assessment is the systematic process of evaluating potential threats and vulnerabilities associated with the disease, including the likelihood of occurrence and potential impact. Risk management is the coordinated set of measures implemented to control, mitigate, or eliminate the identified risks. Information is derived from official sources (e.g. government announcements), informal sources (e.g. media reports and social media posts), and restricted sources (e.g. World Health Organization (WHO) event information site). Aside from manually screening and monitoring information sources, information processing tools (including artificial intelligence) can assist in aggregating and sieving out relevant information. All signals, events, and threats detected must be validated before undergoing initial filtering and triaging. In general, only those pertinent to Singapore are subsequently assessed for risk.

The effectiveness of horizon scanning is closely tied to international cooperation and information sharing, as outlined under international law. Under the International Health Regulations (2005) (IHR), States Parties are required to undertake surveillance and risk assessment activities and inform WHO within 24 hours of events that may be of international public health concern. The WHO will subsequently transmit the necessary public health information to all States Parties, to enable rapid response. Similar notification and collaboration frameworks exist for animal health under the Terrestrial and Aquatic Animal Health Codes, developed by the World Organisation for Animal Health (WOAH).

5.2 Integrated local human infectious disease surveillance

Singapore implements a multi-faceted approach to local human ID surveillance, which combines various surveillance methods to effectively detect and monitor potential and ongoing threats. The information gathered from surveillance is essential for monitoring disease trends to identify populations that are at a higher risk of disease, as well as evaluate the effectiveness of public health and medical measures.

a Indicator-based surveillance

Indicator-based surveillance involves the systematic, routine collection and analysis of structured data on specific health indicators, such as disease cases, laboratory results, primary care, and hospital attendances and admissions. It monitors predefined conditions to track trends, detect outbreaks, and inform public health measures.

Registered medical practitioners and clinical laboratories in Singapore are legally required to notify the Director-General of Health of IDs as stipulated in the First Schedule of the Infectious Diseases (Notification of Prescribed Infectious Diseases) Regulations 2008. Prescribed IDs have to be notified within the stipulated timeframe from time of clinical suspicion, diagnosis, or laboratory confirmation, whichever applicable. Based on known characteristics of diseases, guidance will be provided to medical practitioners and clinical laboratories on the case definitions, testing, and management protocols. Newly identified ID of concern can be prescribed as a legally notifiable disease, to facilitate case reporting and prompt implementation of measures.

Syndromic surveillance focuses on monitoring health-related data that precedes diagnosis and laboratory confirmation. These syndromes – a constellation of specific symptoms – are not subject to mandatory notification but enables the Communicable Diseases Agency (CDA) to detect and monitor outbreaks such as of acute respiratory infections, conjunctivitis, and diarrhoeal illnesses. Further investigations, such as collecting samples for testing, can help identify the underlying ID.

Sentinel surveillance involves systematic collection of health-related data from selected surveillance sites to provide representative and high-quality data on specific diseases or conditions. For example, as part of the National Surveillance Programme for Acute Respiratory Infections (ARI), patients presenting with ARI or symptoms of Influenza-Like Illness (ILI) at designated polyclinics or private general practitioner (GP) clinics may be randomly selected for complimentary polymerase chain reaction (PCR) testing to identify the cause from among a range of commonly circulating respiratory pathogens, including influenza and SARS-CoV-2. This provides timely and representative data on community respiratory disease trends to guide public health interventions and monitor the effectiveness of control measures.

Syndromic and sentinel surveillance approaches are not mutually exclusive, with some surveillance programmes designed to combine both approaches. This integration combines the breadth of syndromic surveillance with the depth of sentinel surveillance.

b Event-based surveillance

This involves analysing anecdotal reports and unstructured information on unusual or significant health events (e.g. unusual occurrences in the number of patients with a particular illness) to enable early detection of disease outbreaks. Healthcare providers, the general public and institutions (e.g. schools, workplaces) can report suspected outbreaks. There is a hospital-based surveillance programme that reviews cases of unexplained deaths and critical illnesses in otherwise healthy individuals to identify novel pathogens early.

c Community testing

Community testing involves systematically testing individuals or groups within the population, regardless of symptoms, infection status, or exposure status. Once the pathogen has been identified, community testing may be implemented in various forms, such as mass testing campaigns, targeted testing in high-risk groups (e.g. persons under quarantine or isolation), or random sampling within a population. It may be implemented in response to an outbreak to better understand the spread of a disease and implement timely control measures. Where feasible, it can be integrated into existing health initiatives (e.g. testing for a new sexually transmitted infection alongside anonymous testing for the human immunodeficiency virus).

Community testing during COVID-19

During the COVID-19 pandemic, Singapore implemented extensive community testing. Routine and mandatory testing, also known as Rostered Routine Testing (RRT), was conducted on front-line workers with high risk of occupational exposure, workers in sectors where there were interactions with vulnerable populations, and individuals working or living in communal settings. Samples from multiple individuals were pooled into a single test to increase testing efficiency and coverage, with individual samples tested only if the pooled sample was positive. When clusters were identified, such as at markets and shopping malls, mass testing was also conducted for visitors to those locations.

Community testing aims to break the chain of disease transmission by identifying and isolating infected individuals early, even if they never display symptoms (i.e. asymptomatic) or before symptoms start (i.e. presymptomatic). Measures such as the tracing and quarantine of contacts could be implemented to prevent further spread. Additionally, the data collected provides valuable insights into the overall disease prevalence, geographical distribution and risk factors, which guides the implementation of additional measures.

The tests used should preferably have high sensitivity and specificity to minimise false positives and negatives. The choice of testing methods will depend on the disease, the size of the target population, resources available and turn-around time for results. Where necessary and possible, testing may be made accessible to all at-risk individuals by addressing barriers such as cost, location, and language to encourage participation.

d Laboratory-based surveillance

Laboratory-based surveillance relies on the CDA's National Public Health Laboratory (NPHL) and diagnostic laboratories to detect, track and respond to emerging health threats. In response to novel and emerging IDs, the NPHL will rapidly develop testing protocols tailored to detect the specific pathogen with high sensitivity and specificity to ensure accurate and reliable diagnosis. Diagnostic laboratories provide real-time data for patient management and outbreak detection by testing patient samples to identify and confirm infections in clinical settings. Diagnostic laboratories are required to submit specific samples to the NPHL to support national surveillance, outbreak investigation, and public health response. The NPHL may conduct further testing to identify the specific characteristics of the causative pathogen and monitor its changes over time to track disease trends, detect novel variants, and validate diagnostic methods. Common laboratory testing methods include:

- Culture to isolate bacteria or viruses from clinical specimens;
- Standard PCR testing to detect genetic material from a pathogen;
- Antigen detection to identify specific component of the pathogen;
- Serology testing, which involves taking a blood sample to test for antibodies to the pathogens;
- Genotyping to identify specific subtype(s) based on the genomic composition of the pathogen; and
- Whole genome sequencing (WGS) to further characterise the pathogen at the genomic level and identify genetic similarities and differences between isolates.

Laboratory surveillance for influenza and levels of population immunity

An example of laboratory surveillance is the influenza virus surveillance under WHO's Influenza Surveillance and Response System. As the National Influenza Centre, the NPHL characterises the influenza viruses from respiratory specimens taken from hospitalised patients and those presenting with ILI at sentinel surveillance clinics. Additional testing is performed for untyped and untypeable influenza A samples. Advanced antigenic and genetic analysis of respiratory specimens from severe cases and outbreaks are also carried out to monitor circulating influenza viruses. This approach allows the early detection of particularly severe or infectious strains for swift implementation of targeted public health measures.

Another example is the national seroprevalence surveys. Samples from different age groups are collected to assess population herd immunity against specific diseases, and to evaluate the effectiveness of immunisation programmes.

Local ID surveillance also adopts a One Health approach, by incorporating the surveillance of animals, food, water, wastewater, and the environment. This recognises the interconnectedness of humans, animals, plants, and the wider environment. In Singapore, the One Health agencies include the CDA, National Environment Agency (NEA), National Parks Board (NParks), Singapore Food Agency (SFA), and Singapore's National Water Agency (PUB). Integrating data across these sectors provides a more holistic view of potential health threats.

e Surveillance of animals

Surveillance of animals aims to prevent and manage zoonotic diseases that can be transmitted between animals and humans. Animals are categorised based on their interactions with humans and their settings, which influence the public health risk they pose:

- Occupational animals are animals that humans interact with in work settings (e.g. working dogs);
- Wildlife are animals in their natural habitats that may come into contact with humans due to habitat encroachment;
- Urban animals are animals that coexist with humans in urban environments (e.g. pigeons);
- Pets are domesticated animals that are kept for companionship or other commercial purposes; and
- Food-producing animals are animals raised for products or by-products for human consumption.

The Animal and Veterinary Service (AVS) of the NParks, along with the SFA, conducts systematic monitoring and biosurveillance of animals, both imported and resident, including laboratory testing.

Horizon scans and risk assessments are conducted to anticipate and prepare for emerging threats. Animals and animal products must also meet the AVS' import requirements, including pre-export tests for zoonotic infections. At checkpoints, stringent biosecurity checks are conducted on live animals and animal products to ensure compliance with veterinary import conditions. Live animals may be placed under post-import quarantine at the Animal Quarantine Centre or designated satellite quarantine stations. For illegally imported animals without known health statuses, active surveillance (e.g. sampling and testing for ID of concern, such as rabies and canine parvovirus) will be carried out due to the higher biosecurity risk they pose.

Surveillance of imported birds and poultry farms

Faecal swab samples are taken from imported ornamental birds for surveillance for avian influenza.

In addition, surveillance of poultry in local farms involves requiring farms to report specific health abnormalities in their flocks and regular testing of chickens for zoonotic diseases. Regular education and outreach are also conducted for community stakeholders and agricultural sector to raise awareness of key diseases to facilitate early reporting.

Local surveillance is supported by

- Mandatory reporting of suspected or diagnosed AVS-notifiable zoonotic disease by veterinarians and follow-ups with the relevant parties (e.g. reporting veterinarian, animal's owner, etc), including ground investigations, if warranted;
- Regular bio-surveillance programmes for local community animals, wildlife, and food animals;
- Syndromic surveillance for specific threats like avian influenza and may be followed by further investigations, if warranted;
- Regular education and outreach for relevant stakeholders in the community and agricultural sector to raise awareness of key diseases to facilitate early reporting; and
- Regular contingency planning, emergency scenario simulations and practice drills for zoonotic diseases of concern (e.g. rabies, highly pathogenic avian influenza).

f Surveillance of food

The SFA oversees food safety and food security in Singapore. Singapore imports over 90% of its food. The SFA has in place an integrated farm-to-fork food safety system, with a risk-based approach aligned with international standards, while enabling the emergence of new food and food innovations.

Food surveillance is carried out through a range of measures – inspection, sampling, and testing for microbial pathogens are conducted for both imported food and locally manufactured food to ensure compliance with stringent food safety standards. The regime prioritises food type, source country, and importer's compliance history, taking into consideration the SFA's horizon scanning of global reports of unsafe food detected by overseas regulators as well as the SFA's own market monitoring of products for sale in Singapore.

The SFA regularly monitors food products in the market to identify any potential food safety risk. Food businesses are also subjected to inspections based on the licensee's track record of compliance. The SFA identifies food products for food safety tests based on various sources of information, such as industry and public feedback, the SFA's own surveillance, and alerts from overseas counterparts.

An example of foodborne disease that may cause outbreaks

Cholera, caused by the bacterium *Vibrio cholerae*, has been responsible for numerous epidemics and seven global pandemics since 1817. The disease spreads primarily through contaminated water and food, causing severe diarrhoea and dehydration. Cholera exemplifies how poor sanitation and lack of clean water can fuel rapid disease spread. More recently, the 2010-2019 Haiti cholera outbreak, which began after the earthquake, resulted in over 820,000 cases and nearly 10,000 deaths. Cholera continues to cause outbreaks today, particularly in areas with inadequate sanitation and healthcare infrastructure.

g Surveillance of water

The PUB conducts a regular and extensive sampling and monitoring programme to ensure water quality from source to tap. The programme tests for pathogens in Singapore's water supply that may cause gastrointestinal, respiratory, and neurological diseases, as well as hepatitis. Water samples are collected from reservoirs, through treatment plants, to distribution points, as well as NEWater facilities producing ultrapure water. The monitoring frequency is tailored to pathogen characteristics and relevance in various water matrices.

h Surveillance of wastewater

Infected individuals may shed pathogens through their stools, sputum (phlegm), urine, or other excretions into wastewater. The NEA conducts surveillance of wastewater in the community to provide early warnings of potential outbreaks and monitor disease trends. The PUB supports the CDA's and NEA's wastewater surveillance efforts by facilitating access to sampling points in the sewer network. The sensitivity of wastewater testing differs for different diseases, and positive signals may help to determine whether additional case finding efforts are needed.

Wastewater surveillance during the COVID-19 pandemic

Singapore was an early adopter of wastewater surveillance (WWS) for tracking COVID-19 spread, commencing testing as early as February 2020. This non-intrusive surveillance approach involved screening wastewater samples for SARS-CoV-2 shed by infected individuals through their stool or respiratory discharges.

The WWS network expanded progressively to include more than 500 autosamplers nationwide, enabling both wide-area and highly localised community monitoring. At the peak of the pandemic, up to 5,000 samples were tested weekly. Academic institutions and commercial partners contributed to developing innovative sampling and detection methods.

Beyond COVID-19, wastewater infrastructures and genomic sequencing capabilities were expanded to monitor other infectious diseases threats, including Zika and mpox. The testing of aircraft wastewater from a network of airports could provide indications of disease transmission trends globally.

Surveillance of vectors

Vectors are living organisms that can transmit infectious pathogens between humans or from animals to humans. The five main vectors in Singapore are mosquitoes, rat fleas, rats, cockroaches and flies. The NEA monitors vector populations and the emergence of vector-borne diseases in Singapore through surveillance programmes.

Surveillance of biting arthropods in Singapore extends beyond *Aedes* mosquitoes to include other species such as *Culex* mosquitoes, sandflies, and biting midges. . For mosquitoes, surveillance efforts involve trapping adult mosquitoes using an extensive network of Gravitrap® and NightCatcher, identifying breeding sites, sampling larvae, and conducting genetic and pathogen analysis to understand their distribution, abundance, and infection potential. Sandflies and biting midges are monitored in high-footfall natural areas where they may pose environmental or health risks, and multiple habitats such as coastal regions, wetlands and forested areas. These surveillance efforts include the use of specialised traps and environmental surveys to detect their presence and assess their population dynamics.

The NEA carries out surveillance of the rat population using various methods which include setting bait stations, detection of burrows, tracking rodent activity through droppings and gnaw marks, and employing thermal imaging or motion detection technology for population assessments and movement monitoring. Data collected is used to identify hotspots and inform targeted control measures, such as trapping, baiting, and habitat modification to reduce food and water sources.

This comprehensive vector surveillance and analysis with other epidemiological data enables the NEA to effectively track vector populations, identify potential hotspots, perform risk assessments and work with relevant stakeholders and premises managers to implement timely interventions to safeguard public health in Singapore.

Surveillance of the environment

Research and ground surveillance are critical for the NEA to maintain environmental public health standards in Singapore, in addition to enforcement, licensing and outreach. The NEA conducts environmental sampling and risk assessments to monitor contamination levels, evaluate the effectiveness of cleaning and disinfection protocols, and guide infection control measures. On top of that, surveillance and risk assessment are also carried out to understand the prevalence of antimicrobial resistance in both natural and built environments, across different environmental matrices such as air, surfaces and water (such as wastewater and coastal waters), to determine levels and risks to public health.

The NEA employs microbiological and analytical chemistry expertise to test for pathogens, and indicators of microbial contamination and chemical pollutants.

An example of an invasive mosquito vector that may cause outbreaks

Anopheles stephensi is an example of a potential invasive mosquito vector. It is a primary malaria vector historically found in South Asia and the Arabian Peninsula but has rapidly expanded its range since 2012. *A. stephensi* is transmitted to new areas primarily through international trade and travel, particularly via seaports and along major transportation routes. While the majority of introduced mosquito species may not establish due to unfavourable conditions, *A. stephensi* has shown a remarkable ability to adapt to diverse habitats, including urban environments, and can persist year-round.

Analytical methods

Analytical methods are used to integrate and interpret surveillance data to enhance our understanding and management of ID outbreaks. They transform data into actionable insights, enabling informed decision-making for both immediate response and long-term strategy.

5.3 Epidemiological investigations

Epidemiological investigations involve the study of patterns, causes, and effects of an ID within a population. In the context of an outbreak response, these investigations aim to:

- Identify potential new cases for follow-up actions such as testing, isolation or medical treatment;
- Detect the source of infection;
- Understand the risk factors and transmission patterns; and
- Reduce onward transmission when combined with measures such as quarantining identified contacts and providing them with prophylaxis.

Epidemiological investigation typically encompasses the development of case definitions, contact tracing, data collection through interviews and surveys, environmental sampling and testing, and statistical analysis. Advanced techniques like genomic sequencing may also be used to track transmission chains and identify outbreak clusters.

These investigations complement routine surveillance data by providing deeper insights, enabling evidence-based decisions for control efforts. If investigations identify specific high-risk settings or activities, the authorities can implement targeted measures such as temporary closures of premises or enhanced hygiene protocols.

5.4 Risk assessment

Risk assessment involves quantifying the probability and impact of pathogens and outbreaks to Singapore and its residents. This process helps inform the need for and focus areas of PHSM and medical countermeasures. Our overall preparedness and response strategy is therefore guided by risk assessment (see Section 2, Chapter 4).

A rapid risk assessment, conducted when a threat first arises, aims to provide a quick qualitative assessment of the immediate risks to guide urgent decisions. These assessments must be performed regularly to account for evolving epidemiological situations or changes resulting from implemented measures. This process involves:

- Formulating relevant questions to define the scope of assessment;
- Collecting evidence about the disease or outbreak, alongside literature review and obtaining expert inputs; and
- Characterising the risk posed to Singapore qualitatively, considering both the likelihood of an event occurring and its potential consequences.

A quantitative risk assessment is typically implemented for well-defined and understood contexts where quantitative data is available, such as from indicator-based surveillance (e.g. COVID-19 disease incidence, vaccine coverage).

Joint risk assessments are conducted among One Health agencies to evaluate the risks of ID at the human-animal-environment interface. Using shared data and expertise, the process examines factors such as disease transmission pathways, zoonotic potential and environmental changes.

5.5 Mathematical modelling

Using the data collected via local and external-facing surveillance systems, modelling tools are used to:

a Perform real-time analysis to understand the drivers of an outbreak and provide short-term forecasting

During an outbreak, it is critical to estimate its epidemiological characteristics, including at the individual-level, group-level and population-level. Modelling can also help to identify risk factors for transmission and severe infection outcomes, to determine the required targeted outbreak control measures. By integrating the observed data with models, short-term forecasts on resource demands, such as for contact tracing, quarantine and healthcare capacity, can be constructed.

b Project anticipated outbreak trajectory under varying outbreak control measures

Outbreak control measures could evolve across the course of the outbreak, due to the availability of new diagnostic tools and vaccines, emergence of new pathogenic variants or variations in population level immunity against circulating pathogens, among many other factors. These measures can be incorporated into models, and sensitivity analysis performed to evaluate changes to the projected outbreak trajectory.

c Evaluate the effectiveness of outbreak control measures

With a modelling framework, counterfactual scenarios can be simulated, for example an outbreak in the absence of control measures, to determine the number of infections averted with existing measures. Additionally, optimal combinations of measures can be explored to determine its impact on the society and economy disruption, and to adjust plans accordingly.

The type of model to use would depend on factors such as the public health questions of interest, the types of data available and the transmission process. Mathematical models (e.g. compartmental models, network models) are typically used to provide projections for population-level transmission dynamics, and statistical models (e.g. regression, likelihood inference models) for individual-level infection outcomes or pair-level transmission dynamics. These models require frequent recalibrations based on new data and evolving circumstances to remain relevant.

5.6 Forward planning

Forward planning is an anticipatory process involving scenario analysis, resource planning and policy development, to predict, mitigate and respond to future scenarios. In an outbreak, risk assessment, trend analysis and modelling can be relied on to:

- Forecast possible scenarios;
- Predict future needs and outcomes, to determine optimal distribution of resources; and
- Create comprehensive and flexible public health policies that can adapt as situations evolve.

Chapter 6: Point of Entry (PoE) measures

Singapore's interconnectivity to the world as a major trade and travel hub makes it particularly vulnerable to the importation of IDs. Countries may take time to effectively manage and contain outbreaks within their borders. Consequently, PoE measures implemented at Singapore's air, sea, and land borders are critical to delay or minimise the risk of importation, prevent local spread of IDs of concern, and buy time to ramp up healthcare capacities and other public health measures.

PoE measures are typically employed in Singapore when the disease is spreading in other countries and there is limited or no community transmission in Singapore. Once there is wider local community spread in Singapore, PoE measures may be less effective or relevant in reducing local disease transmission. Horizon scanning and risk assessment of global threats and country responses help identify areas with ongoing disease transmission and the risk of importation into Singapore. These include assessing the extent of spread within the affected countries, their detection and response capabilities, the occurrence of disease exportation to other countries, and travel volume and connectivity to Singapore. The measures implemented need to be balanced against other non-public health considerations (e.g. economic implications).

PoE measures include, but are not limited to:

- a **General measures** including health advisories for travellers, in-flight/vessel/vehicle mask-wearing requirements, and vaccination-differentiated PoE measures;
- b **Pre-entry requirements** including travel volume reduction, pre-departure testing (PDT), and disinsection, deratisation, disinfection, or decontamination of conveyances and related goods;
- c **Post-entry requirements** including symptom screening at PoE, health declaration and follow-up assessment, on-arrival testing (OAT), risk-based segregation of travellers and workers, and on-arrival quarantine;
- d **Sector-specific measures** to allow movement of workers, animals and food between borders; and
- e **Exit requirements** including symptom screening and testing prior to exiting the country, and time-limited not-to-depart orders on known infected/high-risk persons.

General measures

General measures refer to cross-cutting PoE measures that may apply during peacetime or during disease outbreaks.

6.1 Health advisories for travellers

Health advisories for travellers are official notices issued by the Singapore Government to inform residents and visitors on domestic and international public health issues such as disease outbreaks and potential health risks. These aim to increase awareness about global health situations and guide travellers in making informed decisions regarding their travel plans (e.g. to postpone non-essential travel), health precautions (e.g. hygiene measures and to take relevant vaccine), and treatment (e.g. to seek timely treatment if unwell).

Health advisories for travellers are available on the CDA website and can be broadcasted via press releases, mainstream media, social media platforms, and messages to incoming or outgoing passengers.

6.2 In-flight/vessel/vehicle mask-wearing requirements

The use of face masks (masking) can minimise disease spread. For infected individuals, face masks trap respiratory droplets and aerosols, reducing spread to others. Masking can also protect others from breathing in infectious respiratory droplets and aerosols. Wearing face masks may be required within conveyances to minimise disease spread between passengers. In enclosed settings where individuals are in close proximity for prolonged durations and where air is recirculated, mask-wearing may help mitigate exposure to pathogens that can be transmitted through the air.

Travellers may also be advised to check mask-wearing requirements in destination countries. Temporary concessions to mask-wearing requirements should be considered for essential activities such as during mealtimes, and during emergencies when oxygen mask donning is required.

6.3 Vaccination-differentiated PoE measures

Vaccination-differentiated PoE measures may be implemented at the PoE. Travellers may need to show proof of vaccination prior to entering Singapore. Pre-entry or post-entry PoE measures and requirements may also vary between vaccinated and unvaccinated individuals.

These measures aim to reduce the number of imported cases including severe ones, if vaccination effectively decreases the risk of infection or severe disease. When a disease affects a large number of geographical regions, it may be more effective to distinguish between vaccinated and unvaccinated international travellers, as opposed to measures targeting travellers from many different countries/regions. Successful implementation depends on the ability to verify travellers' vaccination status, which may be facilitated by technological tools such as interoperable digital vaccination certificates.

For unvaccinated travellers, including those who have yet to complete the full vaccination regimen or whose vaccines are not yet effective (e.g. the yellow fever vaccine takes ten days to become effective), they could be managed in a similar manner as unvaccinated persons.

Vaccination-differentiated PoE measures during the COVID-19 pandemic

The Vaccinated Travel Framework (VTF) was launched during the COVID-19 pandemic to facilitate the safe resumption of international travel, where entry requirements were differentiated based on travellers' vaccination status. Under the VTF, fully vaccinated travellers were allowed to enter Singapore without being subject to Stay-Home Notices (SHN) and on-arrival COVID-19 testing.

Pre-entry requirements

Pre-entry requirements are placed on travellers or operators before they depart their country-of-origin for Singapore. These measures aim to reduce the risk of importing cases by either restricting the number of entrants from high-risk countries or detecting cases before they board. Pre-entry requirements are generally less resource-intensive than post-entry requirements and may thus be preferred or used in combination with other PoE measures in a large-scale outbreak.

6.4 Travel volume reduction

Travel volume reduction is aimed at decreasing the number of travellers from identified high-risk countries into Singapore over a given period, thereby reducing the risk of importation and impact on public health resources. The WHO guides that such measures should not impede essential travel such as emergency and humanitarian actions, travel of critical personnel, repatriations, and cargo transport for vital supplies.

The number of daily visitor arrivals allowed may be based on the projected number of imported cases. Implementation could be through requiring travellers to apply for approval before entry to Singapore, or by limiting the number of incoming flights, vessels, or vehicles.

For persons permitted to enter Singapore, such as Singaporeans and Permanent Residents, additional conditions of entry may be implemented. Where feasible, these may be extended to Long-Term Pass Holders.

6.5 Pre-departure testing (PDT)

Travellers may be required to produce a negative PDT result within a stipulated timeframe prior to departure for Singapore. The PDT is to detect cases before they travel to Singapore. The stipulated timeframe (e.g. test to be taken within 48 hours or 72 hours before departure) would depend on:

- Incubation period, which is the time between exposure and when the individual develops symptoms. Shorter incubation periods may necessitate testing closer to departure;
- Detection window. When the pathogen can reliably be detected is dependent on the type of test used (e.g. standard PCR tests may detect the virus earlier but require longer processing times); and
- Type and accuracy of test. High-sensitivity tests are better at detecting early infections while lower-sensitivity tests may miss asymptomatic or early-stage cases.

Travellers who have been tested negative should still be advised to monitor their health closely and seek medical attention if unwell upon arrival in Singapore as they may have been incubating at the point the PDT was conducted.

6.6 Disinsection, deratisation, disinfection, or decontamination of conveyances and related goods

Measures to disinsect, derat, disinfect, decontaminate, or otherwise treat baggage, cargo, containers, conveyances, goods, or postal parcels should be applied to minimise disease transmission through surfaces and vectors. These measures may include the use of approved agents (e.g. disinfectants, insecticides, or rodenticides) that are effective against specific pests or pathogens.

Specifically, if the disease of concern is vector-borne, disinsection or deratisation should be carried out to ensure that the vector is eliminated prior to the aircraft or vessel entering Singapore. If there is an environmental risk, the operators may also be mandated to disinfect or decontaminate aircrafts or vessels.

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Post-entry requirements

While travel volume may be restricted and pre-entry testing requirements may detect a proportion of cases before entry into Singapore, these measures may fail to detect individuals who are still within the incubation period. Hence, post-entry requirements may be imposed on travellers upon or after arrival in Singapore to prevent any further transmission to the community. Screening may be conducted to pick up high-risk individuals based on their symptoms, vaccination status, travel history, or test result.

6.7 Symptom screening at PoE

Symptom screening of travellers may be used to detect cases at the PoE before they enter the community. This may include temperature screening using thermal scanners for diseases with fever, or visual screening for diseases with visible symptoms such as rash. Symptom screening may either be targeted at arrivals from specific countries or may be applied universally to all arriving travellers. Symptomatic travellers who are detected via screening would be referred for further medical assessment.

6.8 Health declaration and follow-up assessment

Health declarations may be implemented to screen travellers for existing and emerging IDs of concern. Questions on symptoms, vaccination status, and travel history relevant to the disease may be included in the self-declaration. Travellers with relevant travel history or symptoms compatible with the disease of concern may be referred for follow-up actions, such as on-site clinical assessment, or referred to a hospital for further medical assessment. Suspected cases may then be transported to an appropriate medical facility via dedicated transport with appropriate infection prevention and control (IPC) measures. False declarations can lead to legal implications, including potential prosecution under relevant laws.

6.9 On-arrival testing (OAT)

OAT refers to the testing of travellers immediately upon arrival or after in Singapore, with the aim to detect imported cases early. OAT may be required for travellers from affected countries or all countries in response to the epidemiological situation. Positive cases may be isolated, and other public health actions such as environmental disinfection may follow, to prevent onward transmission within the community.

The considerations for implementing OAT include:

- Disease characteristics;
- Availability of tests with high sensitivity and specificity that can accurately pick up cases;
- Ease of sample collection and invasiveness of sampling method;
- Turnaround time to obtain test results; and
- Testing capacity.

Ideally, rapid diagnostic tests that can provide results quickly for immediate follow-up public health actions would be preferred, as other test modalities including standard PCR and serology tests, while more accurate, have a longer turnaround time and require significant laboratory capacity. However, such rapid tests may also have lower sensitivity and accuracy.

Health declaration via the electronic Health Declaration (eHDC)

The electronic Health Declaration (eHDC), integrated within the SG Arrival Card (SGAC), streamlines the declaration process for travellers, allowing them to submit their health information prior to arrival to Singapore. The digitalised screening questions are updated in response to evolving health situations, ensuring relevant information is collected and facilitating identification of potential high-risk travellers.

6.10 Risk-based segregation of travellers and workers

Travellers may be segregated by risk level at the PoE based on their travel history and health status, to prevent any potential spread. Affected flights/vessels/vehicles and travellers could be processed in separate terminals or zones to reduce interaction with lower-risk groups. Travellers requiring immediate isolation or quarantine would then be escorted directly to dedicated facilities for isolation or quarantine. Workers in high-risk zones may be provided necessary personal protective equipment (PPE) with designated donning and doffing areas, and assigned segregated rest and dining spaces to avoid mixing with workers from other zones.

6.11 On-arrival quarantine

Quarantine refers to the separation and restriction of movement of individuals who had close contact with infected cases, or with a higher risk of exposure based on immunity status or travel history to affected countries. Travellers may be required to undergo on-arrival quarantine to limit and prevent the introduction of the disease and onward community transmission. The duration of the quarantine is subjected to the disease characteristics.

Depending on the public health assessment and capacity constraints, quarantine may be served at home or in dedicated facilities. Legal on-arrival quarantine orders may be issued to enforce compliance to quarantine. Quarantining at home offers comfort t and familiarity, but risks household transmission especially in shared living spaces. In contrast, quarantine at dedicated government facilities (i.e. facility-based quarantine) ensures stricter containment and reduces the risk of spreading the infection within households. It may be prioritised for higher-risk individuals while allowing lower-risk individuals to quarantine at home under monitoring. On-arrival quarantine requirements also depend on how the disease spreads. Diseases that spread through the air or via contact may require stricter quarantine while diseases that spread through food and water rarely require on-arrival quarantine, focusing instead on food and water safety and personal protection measures. For vector or animal borne diseases, special consideration should be taken to ensure that the quarantine location is free of the vector or animal of concern.

Quarantine may be challenging to implement when travel volume is high or for daily commuters (for work or school). Alternative measures such as regular testing may thus be considered to mitigate the risk of further disease spread in Singapore. As quarantine is generally resource intensive, it may be implemented alongside other measures to manage travel volume.

Testing could also be implemented at the start, during or at the end of the quarantine period. Frequent testing may identify infections before symptoms appear, enabling timely medical intervention and reducing severe cases. It also minimises the risk of spread within the facilities.

On-arrival quarantine durin the COVID-19 pandemic

During the COVID-19 pandemic, travellers entering Singapore from higher-risk countries or regions were served a stay order, also known as Stay-Home Notice (SHN). The SHN was a legal order to mandate a designated period of on-arrival quarantine for these travellers. Individuals could serve the quarantine either at their place of residence (if permissible) or a designated SHN facility. Individuals subjected to a SHN were not allowed to leave their place of quarantine during the notice period except for mandatory COVID-19 testing. They were required to monitor their health, take their temperature twice daily, and report their status through a mobile application. The Singapore Government conducted random checks via phone calls, video calls, or in-person visits to ensure compliance.

Sector-specific PoE measures

6.12 Sector-specific PoE measures

Sector-specific PoE measures are crucial to allow safe movement of workers, animals, and food across borders during a pandemic, because of Singapore's trade-dependent economy. Measures for safe movement of workers may encompass protocols such as enhanced health screenings, testing regimes, and strict safety protocols before they travel and upon arrival.

Measures for safe movement of animals or animal products focus on mitigating the risk of importation of IDs, including zoonoses. This includes pre-import conditions, documentation verification for import of animals and animal products to ensure compliance with veterinary import conditions, and on arrival quarantine if required.

Singapore maintains a stable food supply through a strategic approach of source diversification, allowing imports from multiple countries while implementing comprehensive regulatory measures to ensure food safety. Measures for safe movement of food include pre-import source accreditation for food commodities of higher regulatory concern, such as meat, eggs and livestock (e.g. pigs, live poultry) imported for slaughter in Singapore and poultry products, registration and licensing of importers and food businesses (e.g. farms, slaughterhouses, food manufacturers, caterers, restaurants, food courts, coffeeshops, food stalls) with the SFA, permit requirements for imported food consignments, veterinary health certifications for specific food types, and rules and limits for food products that are brought in by travellers for their personal consumption.

Exit requirements

6.13 Exit requirements

Exit requirements are requirements imposed on persons departing Singapore. Exit requirements could be useful to limit disease exportation and protect other travellers and airline crew. These measures may be similar to entry requirements, including symptom screening and testing. Time-limited not-to-depart orders on known infected or high-risk persons may also be implemented.

Sector-specific measures during the COVID-19 pandemic

To ensure the continued transport of food and other essential goods from Malaysia, a vaccination exercise was implemented for Malaysian truck drivers delivering these critical supplies to Singapore. These drivers were "bubble-wrapped" with specific transport routes and designated toilets and loading/unloading bays. Together with contactless deliveries and restricted movement in the community, this minimised community interactions.

For Construction, Marine Shipyard, and Process sectors, which employ a significant proportion of foreign workers, specific entry requirements were established for Work Permit Holders of these sectors. The requirements included processes such as pre-entry vaccination and testing requirements, controlled arrival procedures with designated entry points and transportation, and post-entry onboarding programme. This tightened end-to-end safe management processes helped to bring these workers into Singapore safely and minimise the risk of COVID-19 importation or onward transmission.

Chapter 7: Healthcare provision

Health systems and healthcare service provision serve as a defensive frontline in safeguarding public health and mitigating the spread and impact of a disease during an outbreak.

7.1 Ensuring access to primary care

Strong primary care systems are the first line of defence during outbreaks, helping to detect cases, triage patients and provide community-based care for mild to moderate cases. In turn, critical resources in hospitals can be reserved for severe cases. As of end 2024, there are 26 polyclinics and more than 2,000 private general practitioner (GP) clinics in Singapore. Primary care services for IDs include the diagnosis and treatment of mild acute conditions such as acute respiratory infections (e.g. common cold, influenza, COVID-19) and gastrointestinal infections (e.g. food poisoning, traveller's diarrhoea), as well as the provision of childhood and adult immunisations. Primary care providers also coordinate patient care with other care providers, such as when the patient needs to be isolated, or when urgent or specialist care is needed.

Alongside the polyclinics, participating private GP clinics are mobilised during public health crises under the Public Health Preparedness Clinic (PHPC) scheme to provide subsidised healthcare services, ensuring accessible, affordable and timely care. This reduces barriers to early detection and disease control. This scheme allows the healthcare system to tap into the extensive network of private GP clinics, thus significantly expanding capacity to handle surges in patient demand.

7.2 Strengthening health system resilience

Strengthening health system resilience is essential for ensuring our healthcare system can withstand and adapt to the pressures of outbreaks and safeguarding the delivery of essential care while effectively managing surges in demand and mitigating the widespread the impact of health crises.

a Infrastructure and capacity

As of 2024, Singapore's acute healthcare infrastructure includes 11 public hospitals offering acute and specialist services, alongside nine private hospitals, with additional care options such as community hospitals. To bolster Singapore's preparedness for potential ID outbreaks, the National Centre for Infectious Diseases (NCID), which is Singapore's purpose-built specialty centre, has been dedicated to the prevention, management and control of IDs since its establishment in 2019.

At the start of an outbreak, patients suspected or confirmed to have novel and emerging IDs tend to be managed at the NCID. This centralised approach allows for better pathogen/disease characterisation to better inform clinical management and public health policies. Centralised management at the NCID also preserves other public acute hospitals' services, as it provides adequate buffer time for their transition and ramp-up of necessary resources. When the scale of the outbreak is beyond what the NCID can manage, or if the disease does not require centralised management, the Ministry of Health (MOH) may activate other public acute hospitals to admit suspected/confirmed patients.

Surge capacity planning is incorporated into infrastructure design to ensure healthcare systems can quickly adapt to unexpected demands during public health crises. This involves designing hospitals and clinics with modular spaces that can be quickly repurposed for isolation wards or intensive care units. Temporary structures, such as the conversion of existing facilities for subacute care, and mobile clinics could be pre-planned for rapid deployment.

ⓑ Healthcare manpower and workforce

A robust and adaptable healthcare workforce is vital as they form the backbone of health services provision. This includes providing essential medical care, upholding public health measures, and ensuring the continuity of core health services during outbreaks.

Strengthening the healthcare workforce during outbreaks requires rapid recruitment, adequate training, and robust support systems to ensure resilience and efficiency. This may include enlisting additional personnel, such as retired healthcare workers or medical students, and cross-training staff to take on additional or different roles during an outbreak. It may also require developing a flexible scheduling system that is able to manage rotating teams to reduce burnout yet allow for quick response to surges. Initiatives such as the SG Healthcare Corps will provide an additional pool of trained manpower to support healthcare service provision, while the newly set up Healthcare Reserve Force (HRF) will provide tangible opportunities for the community to contribute directly to our healthcare system's crisis capabilities through augmentation of MOH's operational teams.

Expanding the healthcare workforce during the COVID-19 pandemic

During the COVID-19 pandemic, staff from other sectors affected by the pandemic were deployed to healthcare services through collaborations. An example is the Singapore Airlines (SIA) Group which redeployed more than 2,000 staff to frontline roles in various public agencies and healthcare institutions from March 2020. These included over 900 cabin crew who served as Care Ambassadors to support healthcare institutions in patient care, which freed up nurses and other healthcare staff to devote additional focus on patients who require more complex clinical care. SIA and Scoot staff were also temporarily redeployed as Transport Ambassadors, Contact Tracing Executives, and Social Service Office Processing Officers.

Learning from this experience, the MOH, Public Service Division, and SIA Group signed a Memorandum of Understanding in 2024 to formalise the commitment to collaborate on manpower planning and deployment for future national crises. This includes peacetime training and volunteer deployment of cabin crew in support care roles.

7.3 Prioritising and restructuring care

During an outbreak, prioritising and restructuring care is essential to ensure that resources are allocated efficiently and that patients receive the most appropriate care based on severity and urgency. The public may be urged to refrain from seeking care at emergency departments unless facing genuine emergencies. Triage systems can be implemented to prioritise critical cases while less urgent cases may be deferred or managed through alternative care models, like telemedicine or home-based care. Non-urgent medical care may also be postponed to free up resources, including staff, medical supplies and equipment.

An example of a contact-borne disease that may cause outbreaks

Ebola virus disease (EVD) is an example of a disease transmitted through direct contact with an infected person or indirect contact with surfaces or objects contaminated by the pathogen. The EVD pandemic started in 2013 in Guinea. There had been previous outbreaks of EVD in Central and East Africa, but this was a pandemic of unprecedented scale with 11,000 reported deaths. Its rapid spread across West Africa may be attributed to poor public health infrastructure and porous borders, while international air travel subsequently facilitated its spread to other countries. During the EVD pandemic, enablers used by affected countries, such as local community groups and localised communication allowed for effective deployment of public health measures such as contact tracing and quarantine.

7.4 Implementing appropriate infection prevention and control (IPC) measures and precautions

IPC and other precautionary measures (e.g. management of deceased persons, and visitor restrictions) are essential for safeguarding healthcare workers and ensuring they can provide safe and effective medical care to patients. These measures aim to reduce the risk of healthcare-associated infections, minimise the spread of infectious agents within healthcare facilities, as well as prevent their subsequent spillover into the community.

ⓐ IPC

The key measures, which should remain adaptable to evolving needs and are typically developed in consultation with experts, include:

- Developing guidelines, standards, protocols, and procedures;
- Ensuring appropriate use of PPE;
- Implementing IPC training and education strategies, including just-in-time training;
- Promoting hand hygiene practices;
- Enhancing environmental hygiene, including deploying novel technologies for cleaning and disinfection;
- Strengthening environmental controls, such as improving ventilation; and
- Establishing strategies to maintain surveillance of national IPC indicators and antimicrobial stewardship programmes to control healthcare-associated infections and hospital-onset antimicrobial resistance.

Minimum PPE requirements, cleaning and disinfection strategies, environmental controls, and other IPC measures should be fully reviewed for each pathogen or syndrome to incorporate emerging evidence on pathogen transmission dynamics and IPC.

ⓑ Management of deceased persons

Special handling of deceased persons with emerging IDs may be required in view of the risk of infection to personnel who come into contact with them, and to prevent contamination of the environment, such as water sources. Such personnel may include staff at healthcare institutions, funeral services providers, crematoria and burial grounds. Guidelines on the handling of deceased persons would be issued during an outbreak, guided by pathogen characteristics, risk assessment of exposure and its consequences, as well as the availability of appropriately trained personnel and adequately equipped facilities to handle the deceased. Depending on the disease and mode of transmission, the guidelines may include:

- Training requirements for funeral services providers handling the deceased who were suspected or confirmed cases e.g. the need to complete the Basic Infection Control Course;
- Use of appropriate PPE when handling the deceased;
- Restrictions on body preparation, such as spraying, washing, or embalming due to the risk of fluid exposure and aerosolisation;
- Disposal of used items and potentially contaminated articles in properly labelled biohazard bags to prevent contamination;
- Double-bagging of the deceased and disinfection of the body bag's exterior to contain fluids and prevent contamination;
- Placement in a hermetically sealed coffin;
- Care taken during the transportation of the coffin, including to prevent breakage of the hermetic seal; and
- Safe burial and cremation practices to prevent contamination.

ⓒ Visitor restrictions

Visitor restrictions in healthcare settings during an outbreak are carefully implemented to balance IPC with the emotional and social needs of the patients and their kin. Limiting the number of people entering healthcare facilities reduces the chance of introducing or spreading infectious agents in these vulnerable settings, hence ensuring the safety of both patients and healthcare workers.

SINGAPORE PANDEMIC PREPAREDNESS AND RESPONSE FRAMEWORK

Chapter 8: Medical countermeasures

Medical countermeasures involve the use of PPE, vaccines, diagnostics and therapeutics to prevent, detect, and treat diseases. The measures are critical for reducing transmission, lowering the overall disease burden, and protecting our healthcare system from being overwhelmed. Key medical countermeasures are outlined as follows:

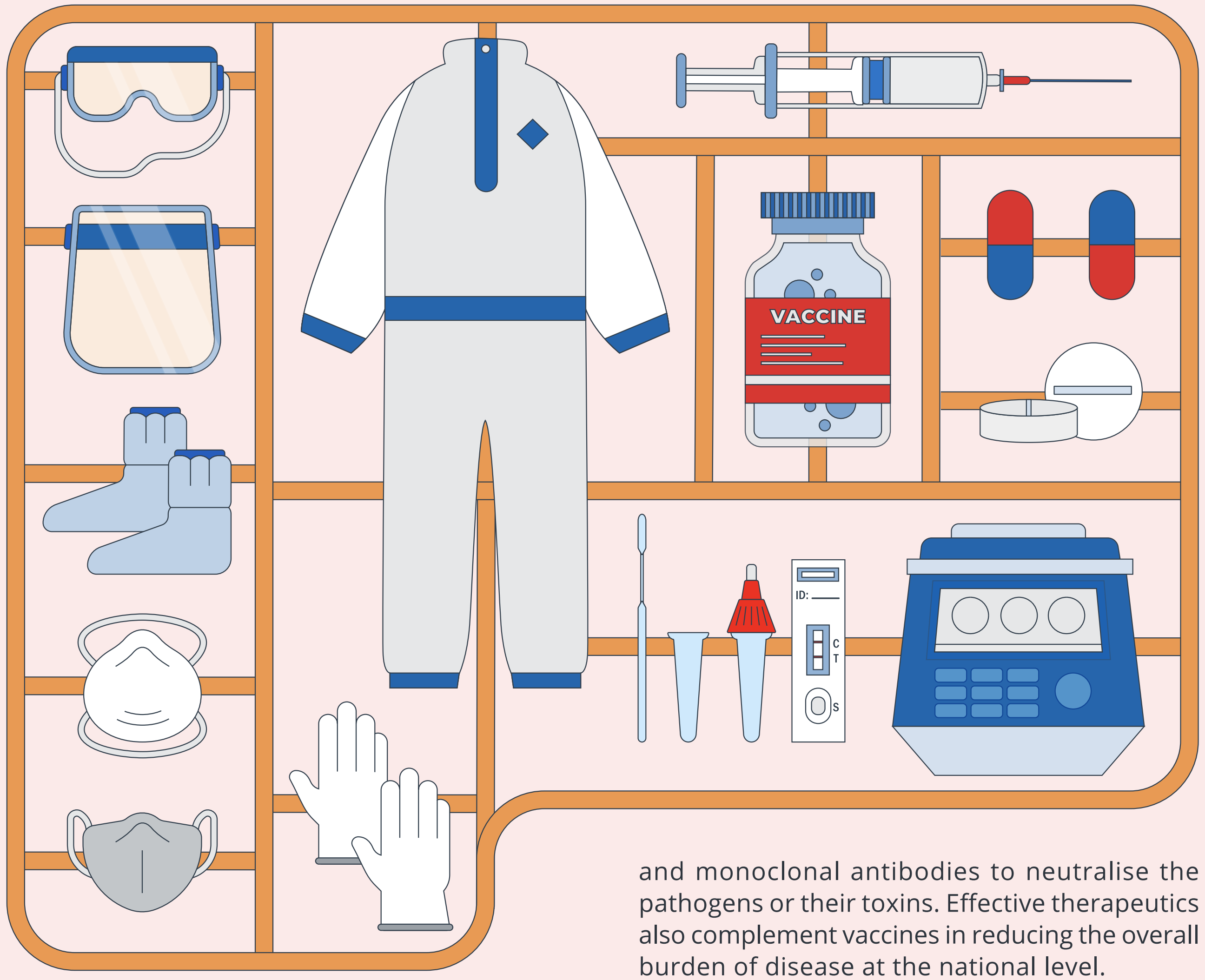
ⓐ **PPE** protects frontline workers who are at increased risk of exposure. This serves to preserve manpower by reducing risk of infection and maintains confidence and morale amongst frontline workers. PPE may include a combination of face masks (reusable, surgical, or N95 masks), eye protection (goggles or disposable face shields), gloves, gowns, or hood depending on the disease characteristic and setting. Face masks may also be applicable for the public to reduce expulsion of droplets if unwell or potentially harbouring the disease.

ⓑ **Vaccines** stimulate the immune system to recognise and respond to pathogens, providing protection by reducing the risk of infection and the severity of disease. It can be used as pre-exposure prophylaxis (PrEP), where individuals receive vaccines before exposure to the pathogen to prepare the body for future encounters with the actual disease. Alternatively, it can be used as post-exposure prophylaxis (PEP), where individuals receive the vaccines after exposure to the pathogen. Vaccines are generally classified into live attenuated and non-live types. Live attenuated vaccines contain weakened forms of the pathogen, capable of eliciting a robust immune response without causing illness, with examples including varicella and yellow fever vaccines. Non-live vaccines, which can contain inactivated whole pathogens (inactivated vaccines) or only parts of them (subunit vaccines), generally have a better safety profile, but often provide lower immunogenicity and shorter protection, requiring multiple doses or adjuvants to enhance effectiveness. Examples of inactivated and subunit vaccines include polio vaccines and pneumococcal vaccines, respectively. A newer generation of non-live vaccines includes viral vector vaccines, which use non-pathogenic viruses to express pathogen protein genes that elicit an immune response, and nucleic acid-based vaccines, such as DNA and mRNA vaccines, which use genetic material to instruct cells to produce pathogen-related proteins that stimulate an immune response.

ⓒ **Test kits** support the detection, management, and control of IDs by enabling timely and accurate diagnoses. Test samples are most commonly collected through blood, and nasal and throat swabs; however, other samples like sputum and stool can also be utilised. Common testing methods, organised by how fast results are produced and overall turnaround time, include:

- **Rapid diagnostic tests**, which typically provide results within minutes to a few hours and may be performed at the point of care, are used to quickly detect pathogens, antigens, antibodies or genetic material from a sample. These tests facilitate prompt isolation and treatment of patients and are particularly useful for mass testing due to their lower logistical requirements. Examples include antigen rapid tests and rapid PCR tests.

- **Standard laboratory tests**, which typically provide results within hours to several days, offer more detailed and accurate results compared to rapid diagnostic tests, with higher sensitivity and the ability to detect infections at earlier stages, making them especially useful in the initial stages of disease outbreaks. Examples include standard PCR tests (which detect the genetic material of the pathogen to identify infections) and serology tests (which identify antigens or antibodies in the blood to indicate immunity from past infection or vaccination).



- **Complex tests**, which typically provide results within several days to weeks, are advanced diagnostic methods that offer detailed information about pathogens, including specific strains or mutations that may affect treatment options. These tests are particularly useful for detailed diagnostics and outbreak investigations, especially when more in-depth information about the infection is needed. An example is WGS to further characterise the pathogen at the genomic level and identify genetic similarities and differences between isolates.

ⓓ **Therapeutics** play a crucial role in prevention and disease management. Therapeutics may be administered prior to or soon after exposure to reduce likelihood or severity of disease. Therapeutics can also be administered after an infection has occurred and are focused on reducing symptoms, speeding recovery, or preventing complications. Examples of therapeutics include antibiotics for bacterial infections, antivirals for viral infections, antifungals for fungal infections, antiparasitic drugs for parasite infections, and monoclonal antibodies to neutralise the pathogens or their toxins. Effective therapeutics also complement vaccines in reducing the overall burden of disease at the national level.

The overall medical countermeasures strategy focuses on ensuring that safe and effective medical countermeasures are available to prevent, detect, and treat IDs during an outbreak. This strategy comprises four main components: (i) research and development, (ii) regulatory approval and recommendations for use, (iii) stockpiling and supply chain management, and (iv) deployment and implementation.

For new IDs, medical countermeasures may not be immediately available, as their development requires extensive research, testing, and regulatory approval, which could take months or even years. The timeline from development to deployment of these medical countermeasures can vary significantly depending on the pathogen, availability of technology, and the complexity of creating an effective and safe medical countermeasure. During this period, it is crucial to implement other PHSM to manage transmission and allow sufficient time for the development, approval, and deployment of medical countermeasures.

8.1 Research and development (R&D)

The research and development (R&D) of medical countermeasures, ideally conducted during peacetime, aim to ensure speedy development for timely access to effective interventions during outbreaks, without compromising safety and public health. Singapore supports this through investments in local biomedical R&D capabilities via grant schemes and human capital awards, fostering innovation and expertise. These efforts focus on exploring innovative technologies alongside existing ones, optimising clinical trial processes, and ensuring diverse population representation in studies to validate safety and effectiveness.

8.2 Regulatory approval and recommendations for use

In line with the WHO's guidelines, Singapore has regulatory frameworks for medical countermeasures to be approved or authorised for use. This includes flexible regulatory pathways to authorise new products under emergency conditions, based on a risk assessment of public health.

Regulatory agility is important in facilitating the expeditious authorisation and supply of medical countermeasures that can detect, prevent and treat the disease. For example, the Health Sciences Authority provides an avenue for early access to critical novel vaccines, medicines, and medical devices during a pandemic through the Pandemic Special Access Route.

In parallel, experts in IDs, immunology, and other relevant fields would provide recommendations on the use of such medical countermeasures during an outbreak. Clinical guidelines would be developed, taking into consideration disease characteristics, the eligible population for whom the tests, vaccines, and therapeutics should be recommended and prioritised. Following initial deployment of a medical countermeasure, continual monitoring for new data that emerges globally and locally is carried out. This ensures that recommendations on its use can be updated accordingly.

8.3 Supply chain management

Consistent with the WHO's recommendations, Singapore maintains stockpiles of essential medical countermeasures, diversifies sources and supply chains, and invests in local production capabilities that we judge essential and feasible. These efforts aim to ensure availability of supply and guard against future disruptions during crises.

To ensure the availability of essential medical countermeasures during crises, key considerations include:

- Scientific evidence on the effectiveness and shelf-life of medical countermeasures;
- Cost-effectiveness and operational feasibility;
- Regular review and updating of stockpile composition to meet evolving needs;
- Strategies to ensure supply chain resilience; and
- Logistics and storage capabilities, including specialised facilities, where required.

8.4 Deployment and implementation of medical countermeasures

Effective deployment and implementation of medical countermeasures require careful planning and coordination to ensure swift and effective delivery to affected populations. The approach is guided by key considerations which include:

- Timely distribution through a well-established supply chain network. This involves determining the capacities and locations for testing, vaccination, or drug dispensing operations, assessing the required healthcare manpower and implementing the necessary information technology systems to support the processes;
- Regular training of healthcare manpower on the safe administration of vaccines and

treatments, protocols for handling adverse events, and appropriate methods of donning and doffing of PPE;

- Identification and prioritisation of specific populations, such as high-risk groups, or geographic regions for deployment. High-risk groups may include persons with elevated risk of severe disease or death (e.g. persons with comorbidities) and persons at higher risk of being infected (e.g. frontline workers);
- Public communications on the availability, usage, and importance of the medical countermeasures; and
- Surveillance and monitoring of the effectiveness and safety of the medical countermeasures, including implementing feedback mechanisms to assess gaps and adapt the deployment strategy as the situation evolves (e.g. deploying mobile testing, vaccination, or drug dispensing teams to facilitate ease of access).

Vaccination as a key strategy in our preparedness against airborne diseases

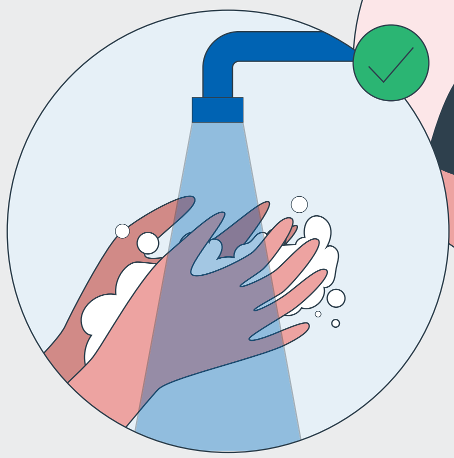
Smallpox is an example of a disease that transmits through the air. It is a severe ID caused by the variola virus, characterised by fever, body aches, and a distinctive progressive skin rash. The disease has caused significant epidemics throughout history. Through an effective vaccination programme, there have been no cases of naturally occurring smallpox since 1977, and this disease has been declared eradicated worldwide in 1980.

COVID-19 is another example of a disease that transmits through the air. The COVID-19 pandemic is caused by the SARS-CoV-2 virus and began at the end of 2019. The virus's transmission characteristics contributed to its rapid spread across multiple regions due to high travel volumes driven by the year-end and new year holidays. The development and rollout of COVID-19 vaccines marked a turning point in the pandemic response. Mass vaccination campaigns, beginning in late 2020, significantly reduced severe illness, hospitalisations, and deaths. Vaccination allowed countries to gradually resume daily activities and supported economic recovery. These vaccination efforts demonstrated the crucial role of immunisation in controlling infectious diseases and enabling society's recovery from public health emergencies.

Chapter 9: Population-based measures

These measures reduce the transmission of IDs at the individual level (from infected or exposed individuals or animals to others), and at the community level, such as the broader population or specific groups. These measures could be applied from the early stages of outbreak prevention and containment to later stages of outbreak management and mitigation. These measures can be grouped into five broad categories:

- (a) **Personal protection measures**;
- (b) **Physical distancing measures**, which include safe distancing, capacity limits, workplace requirements, group size limits and physical separation barriers;
- (c) **Movement restriction**, ranging from individual restrictions to community zoning and countrywide lockdowns;
- (d) **One Health control measures**; and
- (e) **Sector-specific control measures**, specific to businesses and organisations, frontline workers (FLWs) and essential service personnel (ESP), educational institutions, residential and community-based facilities serving the vulnerable populations, and congregate settings.



Personal protection measures

9.1 Personal protection measures

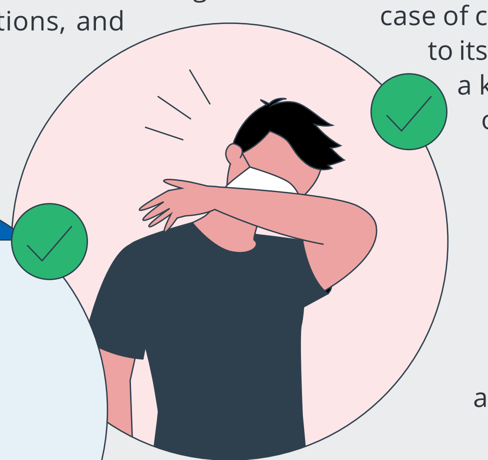
Individuals can adopt personal protection measures to safeguard themselves and others from being infected with and spreading IDs. These guidelines and measures are typically developed as good practice for the public based on the transmission dynamics of the pathogen.

(a) Hand hygiene

Proper hand hygiene is the basic infection control measure to prevent the spread of IDs. This is because high-touch surfaces may be contaminated by pathogens. This can be achieved through handwashing using soap and running water, or by applying 70% alcohol-based hand rub.

(b) Protective face mask-wearing

Protective face mask-wearing serves as source control to reduce transmission from infectious persons and provides personal protection in case of contact with infected individuals. Due to its effectiveness, mask-wearing remains a key public health measure for future outbreaks involving pathogens that spread through the air. Exceptions to masking may be considered, such as during strenuous exercise or for young children. Masks with good filtration capability, such as single-use or reusable ones with at least 95% bacterial filtration efficiency are recommended.



c Respiratory hygiene

Respiratory hygiene, also known as cough etiquette, aims to reduce disease transmission via respiratory droplets and aerosols (i.e. through the air). This includes covering the nose and mouth when coughing or sneezing, followed by performing hand hygiene.

d Environmental hygiene

Environmental hygiene helps address infectious agents that may remain viable on surfaces. However, the specific methods of environmental hygiene vary significantly depending on the disease. For diseases like those that transmit through the air and contact, environmental contamination plays an important role in transmission, necessitating rigorous cleaning and disinfection protocols performed regularly. In contrast, for other transmission modes such as vector-borne diseases, environmental hygiene may not be a key factor.

Environmental hygiene includes regular cleaning and disinfection of common areas, facilities, high-touch surfaces and toilets. Aside from public or common spaces, it is especially important when isolation or quarantine facilities are shared. Potentially contaminated materials, including linen and waste, should be safely managed and properly disposed of to prevent onward transmission. The level of precaution needed in handling these materials differs based on the mode of transmission, infectivity and environmental stability of the pathogen.

Assessment of disinfectants effective against COVID-19

To guide consumers during the COVID-19 pandemic, the NEA released a list of household disinfectants assessed to be effective against COVID-19 virus on 4 February 2020. This list included suitable active ingredients, their effective concentrations and recommended contact times, assessed based on published scientific studies on coronaviruses and data provided by suppliers. This list was updated regularly as new data emerged.

e Effective ventilation and the maintenance of good indoor air quality

Ventilation and indoor air quality are key aspects of maintaining a healthy indoor environment to prevent the spread of diseases, particularly those that are transmitted through the air, which is exacerbated in enclosed settings. Ventilation, which involves bringing in fresh outdoor air and removing stale indoor air, improves air quality by reducing the concentration of pathogens in the air. Air cleaning (e.g. with high-efficiency filters) can also supplement ventilation to increase the amount of clean air supplied to the space. For information on indoor air quality management to reduce the risk of airborne transmission in indoor spaces, premise owners should refer to Singapore Standards SS553 and SS554, as well as guidance issued by the NEA and the Building and Construction Authority.

f Protective measures against animal-borne and vector-borne diseases

IDs may spread through direct contact with animals, their secretions and excretions, or via vectors like mosquitoes and ticks. Avoiding contact with sick or wild animals or consuming wild game, and ensuring pets are vaccinated and treated for parasites can reduce the risk of infections transmitted through such means.

To effectively manage the risk of vector-borne disease transmission, it is important to keep the vector population low and reduce the human-vector interaction, at the national and the individual level. For vector-borne diseases that spread through mosquitoes, individuals are encouraged to wear protective clothing, such as long-sleeved tops and pants, and apply insect repellents regularly. Sleeping under insecticide-treated bed nets can also provide protection against mosquito-borne diseases. Stagnant water should be removed to prevent mosquito breeding.

Physical distancing measures

Physical distancing measures aim to mitigate disease spread while allowing essential activities to continue. Reducing contact among individuals or between animals and humans can slow community transmission.

The implementation of physical distancing measures should be calibrated according to the public health situation and healthcare capacity. Key considerations include disease characteristics, transmission dynamics, vaccination rates, activity type, setting and duration, crowd density and mixing patterns, infrastructure, and operational feasibility. Based on these, measures may be applied broadly or targeted to specific areas or populations.

Another key consideration in implementing physical distancing measures is to balance broad, straightforward approaches that can be applied across various settings against excessive precision that complicates adherence. Overly specific rules, tailored to numerous individual settings, can create confusion for the public. For example, having different distancing requirements for workplaces, schools, restaurants can be difficult to remember and follow. Instead, consistent and general measures that are simple to communicate may ensure higher compliance and effectiveness.

While effective in controlling disease spread, physical distancing measures may have significant economic and social impacts, including disrupting businesses and livelihoods, social isolation, and mental health challenges. Clear and consistent risk communication can help mitigate some of these impacts by fostering understanding and promoting appropriate adherence to measures.

9.2 Safe distancing measures in public spaces

Safe distancing measures can be implemented in various settings to reduce the spread of IDs, particularly those transmitted through the air and contact. Infrastructure to support safe distancing in public spaces may include physical markers such as floor decals, signs, and barriers to guide the public in maintaining appropriate spacing. Seating arrangements could also be modified, such as blocking off alternate seats in public areas. These strategies can be implemented widely, along with clear communication, visible guidelines, and encouragement of outdoor options where possible. Proactive communications and community engagement are important to ensure compliance and effective enforcement.

Safe distancing during the COVID-19 pandemic

A one-metre distancing rule was applied across different contexts in Singapore, including public spaces, workplaces, food and beverage outlets, public transport, and Educational Institutions. Floor markers placed one metre apart indicated where individuals should stand in queues or in lifts. Public seating such as those in buses and trains, dining establishments or public areas had alternate seats or tables blocked off to enforce spacing.

9.3 Capacity limits

Capacity limits and crowd control measures aim to prevent overcrowding, maintain orderly movement, and ensure compliance with safety protocols. These measures are particularly effective for diseases transmitted through the air or via contact. The maximum number of individuals allowed in a given space at any one time may be stipulated based on factors such as the physical size of the area, safety regulations, and the ability to maintain safe distancing between people. Similarly, crowd control measures are implemented to manage the flow, behaviour, and density of groups of people. These can include physical measures such as barriers, queue systems, and directional signage, as well as operational approaches like timed entry, reservation systems, and the deployment of staff to guide and monitor crowds.

9.4 Workplace requirements

Workplace requirements aim to regulate the proportion of employees permitted to work on-site, with the goal of reducing physical interactions and potential disease transmission in work settings. These measures are particularly effective for diseases transmitted through the air or via contact and can also mitigate the spread of diseases through contaminated shared surfaces in office environments.

During periods of heightened risk, organisations may be required to arrange for their workforce to work from home if feasible, and limit on-site presence to essential staff. As the situation improves, these measures can be gradually adjusted. To support these arrangements, organisations are encouraged to develop and maintain robust business continuity plans, which may include strategies for remote work arrangements, staggered working hours, or split team arrangements. These can reduce interactions among staff and minimise operational impact should there be spread of disease among staff.

9.5 Group size limits

Group size limits define the maximum number of individuals permitted to gather for social activities, including dining out, household visits, and other forms of social interaction. A key objective of this measure is to reduce the opportunity for infection to be seeded within a group, which can then be spread to other groups, thereby limiting the potential for widespread transmission. This approach is particularly effective for diseases that spread through the air or via contact. During periods of heightened risk, group sizes may be strictly restricted, potentially restricting gatherings to household members or a small number of individuals. As the situation improves, these may be gradually relaxed, allowing for larger gatherings.

9.6 Physical separation barriers

Physical separation barriers aim to provide an additional layer of protection against transmission through the air or contact. If transparent, it also helps maintain visual connectivity. In public-facing businesses, such as retail outlets, banks, and government service centres, these barriers may be installed at counters and service points to create a physical shield between staff and customers. Restaurants and food courts could utilise these partitions to separate dining groups, allowing for safer seating arrangements while preserving a social dining experience. In office environments, desk dividers may be employed to create safer workspaces, especially in open-plan offices where maintaining safe distancing might be challenging. Educational institutions could implement these barriers in classrooms and libraries to facilitate face-to-face learning while minimising risk.

Physical barriers should not be relied upon as the sole measure for disease control, but rather as part of a comprehensive strategy that may include other interventions such as improved ventilation, mask-wearing, and hand hygiene practices.

Physical distancing measures during COVID-19

Singapore's Safe Management Measures (SMMs) during the COVID-19 pandemic, often referred to as *SMMs 1-5*, encompassed five key measures:

- **Safe distancing**: This measure required individuals to maintain a physical distance of at least one metre from others in public spaces, workplaces, and social settings.
- **Mask wearing**: The wearing of masks was mandatory in public spaces, with few exceptions such as during strenuous exercise or for young children. This measure was strictly enforced and widely adopted by the population.
- **Group size limits**: Restrictions were placed on the number of people allowed to gather for social activities, including dining out and household visits. These limits were adjusted based on the prevailing infection rates and overall situation.
- **Capacity limits**: Various venues, including shopping malls, places of worship, and entertainment facilities, were subject to capacity restrictions to prevent overcrowding and reduce the risk of transmission.
- **Workplace requirements**: Measures were implemented to reduce physical interactions in work environments, including work-from-home arrangements, staggered working hours, and split team operations.

To effectively reduce transmission, *SMMs 1-5* were implemented in combination, supported by legislative levers and enforcement by various agencies and sector leads, as the measures applied across a wide range of different settings.

Movement restriction

Movement restrictions regulate the flow and interaction of people within geographical boundaries to limit pathogen spread. These measures can effectively slow the progression of an outbreak and reduce peak infection rates.

Movement restrictions can be applied at either the individual or broader community level to control the spread of IDs:

a. **Measures applied at individual level**, which include isolation, contact tracing and quarantine of close contacts, vaccination-differentiated measures, and screening at venue entry; and
b. **Measures applied at the broader community level**, which include cessation of services and lockdowns.

9.7 Isolation

Isolation is the separation of infected individuals from uninfected individuals during the infectious period to reduce disease transmission. The duration of the isolation is subjected to the disease characteristics.

Depending on the public health assessment, isolation may be served at home or in dedicated facilities (i.e. facility-based isolation) with appropriate support and monitoring. Facility-based isolation in NCID, hospitals and dedicated community isolation facilities may be prioritised for vulnerable population who are at risk of severe disease to offer better medical supervision. In some cases, even individuals with mild symptoms might undergo facility-based isolation if they pose a high risk of transmission to vulnerable household members. Factors to consider would include pathogen transmissibility, the individual's living situation, their ability to adhere to home isolation protocols, and the vulnerability of those around them.

The isolation approach depends on how the disease spreads to determine the level of precautions needed. Isolation for individuals with vector-borne and animal-borne diseases will focus on preventing vectors and animals from transmitting the disease to others. This may include keeping infected individuals in vector-proof rooms and instituting protective measures against animal-borne and vector-borne diseases. On the other hand, isolation for individuals with contact-borne diseases will focus on strict physical separation, frequent disinfection and hygiene such as dedicated patient rooms or cohort isolation for those with the same infection. Isolation for individuals with diseases that spread through the air will require well-ventilated rooms for home isolation or negative pressure isolation rooms in hospitals. For foodborne diseases, infected food handlers may be restricted from preparing or serving food until they are no longer infectious.

Testing could also be implemented during the isolation period to determine infectiousness, and guide decisions on when isolation can safely end. Regular testing helps confirm whether an individual is still shedding the virus and remains contagious, preventing premature release that could contribute to further transmission.

Isolation of cases during the COVID-19 pandemic

During the initial phase of the COVD-19 pandemic, all suspect and confirmed cases were isolated centrally at the NCID. With greater understanding of the disease and more established medical protocols, as the number of cases requiring medical care increased, isolation was decentralised to other hospitals and subsequently to community treatment facilities.

During the later phases of the pandemic, Singapore implemented the *Protocols 1-2-3* framework, a risk-based approach, stratifying cases based on their risk of severe disease. This allowed for tailored isolation and quarantine strategies: Protocol 1 targeted high-risk cases, typically elderly individuals or those with comorbidities. Individuals were isolated in medical facilities for close monitoring or if deemed fit by a doctor, they could self-isolate at home with monitoring under the Home Recovery Programme. Protocol 2 was for low-risk cases who could be managed through self-isolation at home. Protocol 3 was meant for close contacts who were guided to quarantine at home with regular testing.

This approach demonstrated how isolation strategies can evolve to balance medical supervision needs with the practicalities of managing a large-scale outbreak, accounting for varying risk levels and individual circumstances.

9.8 Contact tracing and quarantine of close contacts

Contact tracing is the process of identifying persons who may have been exposed to an infectious individual or contaminated environment. Quarantining or monitoring these persons for symptoms aims to interrupt transmission chains and prevent further disease spread within communities. This could be especially important if cases are infectious but are asymptomatic or pre-symptomatic.

Contact tracing involves case identification, activity mapping, contact identification, contact management, and follow-up. Activity mapping reconstructs the movements and interactions of infected individuals during their infectious period. This process helps determine who may have been exposed to the infected individual or contaminated environments. Depending on disease characteristics and the local epidemiological situation, initial contact tracing efforts may focus on identifying all potential contacts. However, as case numbers increase, the focus may shift to high-risk close contacts or settings with vulnerable populations, allowing for more efficient resource use while addressing critical transmission risks. For selected IDs of high public health impact, contact tracing may also be pre-emptively conducted for high-risk individuals who fulfil the suspect case definition (e.g. based on relevant symptoms, travel history, close contact with confirmed cases, or occupational exposure), while pending confirmatory test results, to expedite ring-fencing of contacts. Manual contact tracing may be supplemented by digital contact tracing tools where applicable and available.

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Digital contact tracing during COVID-19

The TraceTogether (TT) Programme was Singapore's digital contact tracing initiative that comprised an app and token, which worked by using Bluetooth signals to exchange signals with other nearby TT devices, enabling the identification of close contacts of COVID-19 cases.

As an extension of the TT Programme, SafeEntry (SE) was Singapore's digital check-in system that logged the information of individuals who visited selected locations to support contact tracing efforts. Individuals who wished to enter a venue where SE was mandatory needed to have either an active TT App or a working TT Token to perform SE check-ins. With SE, the individuals' entry and exit times to a location could be logged.

Quarantine refers to the separation and restriction of movement of individuals or animals who have had close contact with infectious individuals or contaminated environments but are not yet symptomatic. This practice allows for the monitoring for development of illness during the incubation period, and the reduction of further onward spread if the quarantined person becomes infected.

Depending on the public health assessment and available capacity, close contacts may either be quarantined at home or in dedicated facilities. Facilities should be provided for identified contacts who are unable to quarantine effectively at home, such as those living in communal living conditions. To enforce compliance to quarantine, a legally binding quarantine order may be issued. Depending on the vaccination status of individuals, quarantine requirements may be waived or the quarantine duration reduced.

Testing may also be implemented during the quarantine period for early detection of infection, allowing for prompt isolation and subsequent ringfencing of contacts.

If the disease becomes widespread and depending on other disease characteristic (e.g. disease severity) and public health strategy, quarantine may no longer be required for close contacts. Instead, measures could focus on personal and social responsibility, such as self-testing before leaving home for a defined period.

9.9 Vaccination-differentiated measures

Vaccination-differentiated measures help create safer environments in higher-risk settings while maintaining activities. Based on scientific evidence, public health measures may be adjusted according to vaccination status to protect all members of the community against infection and transmission, particularly those who are more vulnerable to severe illness.

Systems for capturing vaccination records and verifying vaccination status, that are accessible to all population segments, would be required for implementation. Mechanisms would need to be in place to provide exemptions from vaccination for those with medical contraindications.

9.10 Screening at venue entry points

Screening at venue and event entry points aims to identify potentially infectious individuals before they enter, thereby preventing the introduction and spread of the pathogen at the event or within the location. Common screening methods include visual checks for symptoms, temperature screening for fever-causing diseases, and checking of pre-event test results or vaccination status.

Key considerations for implementing screening measures include the disease characteristics, presenting symptoms, availability and turnaround time of tests, type of event, expected attendance, available resources, and the epidemiological situation. While screening can contribute to risk reduction, mass gatherings generally require additional measures, and a holistic approach considering the event's characteristics, potential strain on health systems from a large outbreak (e.g. super-spreading incident), and potential economic and social impacts is essential.

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9.11 Cessation of services

Temporary cessation of services, such as schools and businesses, aims to decrease social mixing and potential exposure in high-risk settings. This approach may be broadly mandated for all non-essential services or targeted at high-risk settings to reduce risks of community transmission. Time-bound cessation of services may also be implemented for thorough disinfection. Service cessation could be implemented alongside other public health measures.

In Singapore, the Infectious Diseases Act 1976 provides the legal authority for such measures. Under this Act, businesses or activities may be required to cease, and restrictions may be placed on the movement of persons into and within a specified area, to prevent the spread of an ID. Given the possible economic and social impact following the cessation of services, this measure may be implemented alongside government support initiatives to mitigate disruptions and should be reviewed for calibration when possible.

9.12 Lockdowns

Lockdowns are stringent restrictions on the movement of people and goods into and within specific areas intended to contain the spread of IDs. Lockdowns involve strict limits on movement, often requiring people to stay at home except for essential activities. Lockdowns are particularly effective for diseases transmitted through the air or contact. Such measures must be balanced with considerations of economic sustainability, public well-being, and long-term societal impacts.

Circuit Breaker

The term "Circuit Breaker" in Singapore refers to a set of heightened community measures implemented during the COVID-19 pandemic to curb the spread of the virus. Introduced in April 2020, the circuit breaker was akin to a partial lockdown, designed to reduce social interactions and non-essential movement while keeping essential services operational. During this period, Singaporeans were advised to stay home as much as possible. All social gatherings, such as private parties and social get-togethers with friends and not within the same household, were stopped.

One Health control measures

9.13 One Health control measures

One Health control measures are strategies that integrate human, animal, and environmental health considerations and actions to prevent and manage the spread of IDs. These measures recognise the interconnectedness of animals, food, water, vectors, and the environment in disease transmission. Key measures include:

a Animal control

The AVS regulates the import, export, and movement of animals to minimise the risk of zoonotic diseases. The populations of free-roaming dogs and cats are controlled through sterilisation and responsible rehoming. For wildlife, efforts focus on limiting human-wildlife interfaces such as through regulations on feeding and trade, or mandating training programmes for personnel dealing with wildlife.

In a densely populated and urbanised country like Singapore, where there are close interactions between humans and animals, advisories are issued to educate the public of the do's and don'ts during animal encounters, and targeted vaccinations are provided for urban animal populations at higher risk of disease incursion (e.g. rabies vaccination for dogs and cats at coastal fish farms and outlying islands).

Licensing of pet dogs and cats are mandated to ensure their traceability. Should an animal be suspected or confirmed to be infected with a notifiable disease, measures may include the issuance of an advisory to guide the animal owner on management measures, isolation or movement restriction notice, collection of samples for diagnostic testing, and directives for disease control measures. Joint investigations will also be conducted if a disease affects both humans and animals.

Protocols for proper handling and disposal of dead animals infected with or suspected to be infected with animal diseases would be implemented to prevent potential spillover into the community. These protocols typically include rapid removal of carcasses from public areas, donning of PPE by personnel handling dead animals, proper handling of biohazardous materials, transportation to specific facilities for disposal, often through incineration, and cleaning and disinfection of infected areas.

b Food control

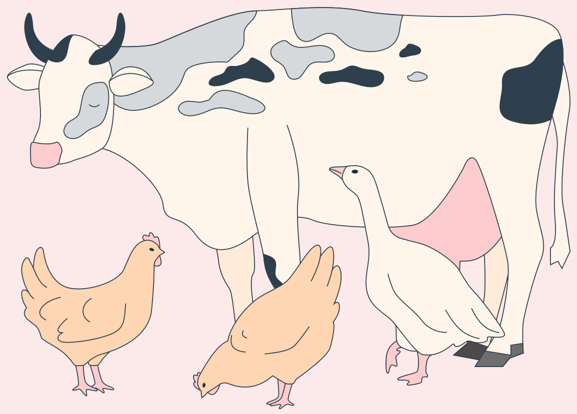
As with the SFA's "farm-to-fork" food safety system, food control measures include accreditation of overseas food sources of higher regulatory concern, import control, inspections, investigations, stringent licensing requirements for food establishments, regular inspections and enforcement of hygiene regulations. The SFA also conducts public education which promotes safe food handling and consumption practices among consumers.

In the event of a suspected foodborne outbreak, investigations would be conducted to establish the cause of contamination, such as a specific food product or handling process. Food safety lapses identified during investigations would be directed for immediate rectification and enforcement actions would be taken. Contaminated food items may be recalled or removed from circulation, and affected establishments may be temporarily closed for sanitation, re-training of food handlers, or rectification of food safety lapses. Affected food handlers may also be identified and banned from food preparation until medically cleared.

The SFA oversees food safety measures to protect public health while supporting the food industry. Singapore's position as a major food importer requires a holistic oversight of the food supply chain. The food establishment management and well-trained food handlers play a key role in reducing foodborne illnesses by ensuring adherence to food safety standards at their establishments. Food establishment management includes restaurant owners, kitchen supervisors, and food and beverage directors, that implement food safety systems, oversee staff training, and ensure compliance with the SFA regulations, thereby significantly contributing to the overall food safety landscape.

An example of zoonotic disease that may cause outbreaks

Avian influenza A(H5N1) is an example of a zoonotic disease which primarily affects birds but can also infect humans and other animals. First identified in humans in 1997, the H5N1 virus has since caused numerous outbreaks in poultry populations across Asia, the Middle East, Europe and Africa. Human infections, while sporadic, have been reported mainly in people with prior occupational or domestic exposure to infected poultry. At times, avian influenza crosses into non-avian species, in particular mammals, causing outbreaks among them. For instance, in 2024, there were outbreaks of H5N1 among dairy cattle in the United States with sporadic spread to dairy farm workers. While the global incidence is low, infected humans can develop severe respiratory illnesses leading to death. To date, there has been no sustained human-to-human transmission of A(H5N1) reported.



c Water and wastewater control

The PUB ensures the safety and cleanliness of Singapore's water supply. The PUB's multi-barrier approaches of treatment, continuous monitoring, and rapid response protocols collectively enable early detection of potential issues, ensure treatment effectiveness, and provide data for informed water management decisions, to maintain the safety and cleanliness of Singapore's water supply.

Prior to distribution, the water undergoes disinfection to remove harmful pathogens, and the minimum Total Residual Chlorine levels is ensured to inhibit microbial growth. To ensure that water remains potable, the distribution system is protected by:

- Maintaining pressurised pipes to prevent inflow of contaminants should there be a leak;
- Enclosed high-rise water storage, with access restricted to authorised personnel and subjected to annual cleaning and disinfection; and
- Strict code of practice to prevent cross-contamination between potable water pipelines and other utility lines such as sewers.

In the unlikely event of pathogen detection in potable water, the PUB may implement measures such as isolating the supply, issuing advisories, and providing temporary supply of clean drinking water through water wagons and the distribution of water bags.

The PUB also regulates the design of sanitary systems and requires the connection of sanitary appliances to be designed with a water seal to act as a barrier to prevent the leakage of sewage gases into each premise through the sanitary appliances. Sanitary pipes of new developments are also required to be air pressure-tested by licensed plumbers to ensure no leakage from the system before they can be commissioned for use. In the event of a disease outbreak, the PUB would disinfect the sewers at quarantine facilities or isolation areas with hypochlorite.

d Vector control

Vector control, under the purview of the NEA, strives for a sustainable disease prevention and control plan that focuses on source reduction as the primary preventive measure. As part of its integrated, evidence-based vector management strategy, the NEA intensifies chemical control measures in response to disease outbreaks. To further improve resilience to vector breeding, there is a deliberate shift to focus on implementing upstream measures to facilitate downstream maintenance to prevent vector issues (e.g. designing out roof gutters, which are difficult to maintain). To ensure the efficacy and safety of these measures, the NEA regulates the sale of pesticides and vector repellents. To complement existing surveillance and control methods, the NEA also explores the use of technology and novel vector control methods. One such example is using Wolbachia-Aedes suppression technology, to reduce the risk of Aedes aegypti-borne diseases.

The NEA undertakes proactive public communication and advocacy efforts to inform and rally support from members of the public to take responsibility for preventing vector breeding on their premises and protecting themselves. This is coupled with a consistent enforcement regime to compel premises owners to eliminate conditions conducive to vector breeding. To enhance resilience against vector breeding, the NEA is shifting towards implementing preventive upstream measures that minimise the need for downstream rectifications and maintenance. This approach includes building design modifications to eliminate potential breeding sites.

Sector-specific control measures

9.14 Sector-specific control measures

Sector-specific measures address the unique challenges and risks associated with different industries during ID outbreaks. Given the distinctive ways in which people interact within each sector, certain groups may face elevated risks compared to the general population. Collectively, these measures help prevent disruptions to societal functions that serve the population's need, while promoting public health.

a Measures for businesses and organisations

Businesses and organisations play a crucial role in maintaining economic stability and essential services during disease outbreaks. To ensure uninterrupted delivery of products and services, it is vital for them to implement robust Business Continuity Planning (BCP). BCP is a proactive process that enables organisations to resume, recover and restore business operations, and soften the impact of sudden and gradual disruptions. This planning is typically undertaken when there are no active disease outbreaks.

BCP is one of the components of a Business Continuity Management System (BCMS) that outlines the overall approach for the development of a new BCP or improvement of an existing BCP. A BCMS has five key elements, which contributes to the overall effectiveness of the system:

- Risk assessment: Identify, analyse, and evaluate potential risks through risk assessment;
- Business impact analysis: Analyse the impact over time of a disruption based on identifying factors such as available resources, prioritising activities to be sustained, and recovery time;
- Business continuity strategies and solutions: Determining short-term and long-term goals based on the priorities identified;
- Business continuity plan development: Consolidate all information from the various analyses and document the details of the steps to take during a disruption; and
- Testing and exercises: Regularly monitor, review and update the plan to ensure its effectiveness.

Business Continuity Planning for COVID-19

Enterprises were encouraged to implement appropriate response measures based on the specific context of their businesses to minimise disruptions to their operations and ensure that their business remains viable during the COVID-19 pandemic. Some examples of BCP components include:

- Implementing flexible work arrangement such as split team schedules, different work locations (e.g. sites, office areas and homes) and telecommuting;
- Reviewing employee management policies such as Stay-Home Notice (SHN), sick leave and workplace closure;
- Identifying critical operations functions and essential employees;
- Providing a safe working environment by establishing safe management measures and regular cleaning and disinfection;
- Ensuring alternative arrangements with suppliers and customers and adhering to safe distancing measures and event organisation guidelines;
- Engaging employees and relevant stakeholders on potential contingency measures and their roles and responsibilities; and
- Keeping up-to-date with government advisories and adapting BCP as the situation evolves.

b Measures for frontline workers (FLWs) and essential service providers (ESP)

While BCP helps businesses and organisations to manage risks at an operational level, specific measures are necessary for FLWs and ESPs to safeguard both their health and the continuity of vital services.

Due to the nature of their work, FLWs face a heightened risk of exposure to pathogens than the general population. Consequently, they may inadvertently introduce diseases into the wider community. To mitigate this risk, additional protective measures may be necessary for FLWs. The stringency of these measures may be tiered based on the level of exposure, such as to high-risk travellers, suspected or confirmed cases and contacts, animals or vectors.

FLWs can be categorised into three groups based on their work activities and the associated exposure risk, including:

- Frontline border workers who interact with potentially high-risk travellers at PoE (e.g. airport workers, shore-based personnel working at seaports, workers at land checkpoints, and air and ship crew);
- Frontline operations personnel involved in containment measures, whose work activities may result in potential exposure to suspected or confirmed cases and contacts (e.g. isolation, quarantine, and conveyance of cases or contacts), and activities leading to prolonged exposure risk such as animal and vector control; and
- Frontline healthcare workers engaged in the diagnosis, treatment, and care of cases.

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ESP are crucial for maintaining the economy and society through the delivery of vital services, without which the functioning of society would face significant disruption. These personnel may work in sectors including, but not limited to:

- Food retail (e.g. supermarkets);
- Health and social services (e.g. hospitals and community care services);
- Government services;
- Transport (e.g. public transport);
- Utilities (e.g. water, energy and environmental related services); and
- Financial services (e.g. banking).

Protective measures for FLWs and ESP to reduce the risk of transmission and infections in workplaces may differ based on their specific roles and operations. These may include:

- Enhanced IPC measures including the use of appropriate PPE, such as masks, gloves, gowns, and eye protection as necessary, hand hygiene, disinfection of common areas, and effective ventilation;
- Pharmaceutical measures such as vaccination and pre-exposure prophylaxis; and
- Physical distancing measures, such as limits in group sizes, mask-wearing requirements, safe distancing in public spaces, installing protective infrastructure (e.g. glass panels) and contactless operations.

To prevent FLWs and ESP from potentially transmitting infections to the wider community, the following measures may be implemented:

- Regular testing regimes, such as RRT to detect cases and isolate them early before further transmission occurs;
- Segregation of staff with high-risk exposure from other individuals with low-risk exposure; and
- Monitoring of symptoms and measures to manage workers who fall ill.

c Measures for educational institutions

Children and youths may be more susceptible to infections due to frequent physical interactions during play and learning activities, and specifically for children, potential challenges with consistently following measures like hand hygiene, physical distancing, and mask-wearing. Depending on specific disease characteristics, children may have different risk profiles for infection or disease complications.

Educational institutions in Singapore, including General Education schools, Special Education schools, Early Intervention centres (i.e. centres which support children who require medium to high levels of early intervention support), preschools, and Institutes of Higher Learning, bring together large groups of students and staff in proximity for extended periods. This environment can potentially facilitate the transmission of IDs.

To mitigate potential risks, educational institution-based measures may be implemented to manage transmission by adjusting the frequency and nature of interpersonal interactions, emphasising hygiene, health monitoring, and infection prevention and control practices. Many of these measures are similar to community measures but contextualised to the educational institution setting while reducing disruptions to teaching and learning, and childcare provision.

Measures may include health screening such as temperature check or visual symptom screening, with guidance for those showing symptoms to stay home and/or seek medical attention. Educational institutions may initiate contact tracing where necessary and provide regular case updates for close monitoring. Enhanced cleaning and disinfection protocols, particularly for high-touch surfaces may be implemented. To minimise close contact, educational institutions may implement safe distancing measures such as staggered recess times, modified seating arrangements, cessation of cross-deployment of staff, and reduced group sizes during activities. Adjustment to assemblies, communal activities, co-curricular activities, physical education, learning journeys, after-school classes, vocational work attachments and overseas trips may be made to align with prevailing health guidelines. Home-based learning (HBL) for educational institutions might be implemented when necessary, with provisions for student lacking digital access.

Public communications regarding these measures are important to reassure parents and address any concerns. Regular health education programmes can be conducted to raise awareness about IDs and teach preventive behaviours. While implementing educational institution-based measures, efforts are made to minimise the impact on learning through digital and hybrid learning approaches. Considering the broader impact, measures such as implementation of limited services for preschools (i.e. only for parents who are essential workers and with no alternative care arrangements) and school closures may be coordinated with work-from-home arrangements to support childcare needs. Even during full HBL implementation, General Education schools, Special Education schools, and preschools may remain open for children without alternative care arrangements (e.g. children of essential service workers) or those lacking conducive home environments for HBL.

Recognising the potential impact of outbreaks and public health measures on well-being, additional support may be provided for students' and staff's mental health and social development. Special arrangements may be necessary to support the caregiving of children with special needs and infants under isolation or quarantine.

d Measures for residential and community-based facilities serving the vulnerable population

Residential and community-based facilities, such as nursing homes, welfare homes, sheltered homes, adult disability homes, children's and youth homes, serve diverse populations with varying health needs. The communal living environment and shared facilities in these settings may require specific considerations for managing IDs. To support the well-being of residents, staff and visitors, these facilities may implement tailored infection control measures. These may include:

- Safe access: (i) Conduct temperature screening and health checks for all staff, residents, visitors and clients, and (ii) restrict the number of visitors per resident and where possible, make arrangements for alternative modes of communications between clients and kin;
- Safe behaviour: Practise and ensure high levels of personal and environmental hygiene; and
- Safe facilities: (i) Adopt physical distancing measures and limit close in-person interactions to essential services and interventions, (ii) heightened infection control and prevention practices; (iii) isolation of cases, which may need to be done in the facility when there are specialised care needs, and (iv) contact trace, with close contacts quarantined and provided medical treatment, if applicable.

e Measures for congregate settings

Dormitories and other similar settings are environments where individuals live or work in closer proximity than in typical residential settings. These arrangements often involve shared living spaces and facilities, which may require specific considerations and measures during ID outbreaks.

To manage the spread of IDs in congregate settings, a range of measures may be considered. These could include enhanced hygiene and sanitation practices such as promoting regular handwashing with soap, providing hand sanitisers, and increasing the frequency of cleaning and disinfection in shared spaces. Improving ventilation may help reduce the risk of transmission through the air where applicable. Education tailored to the audience's needs on recognising disease symptoms and appropriate health monitoring (e.g. temperature checks if relevant) could support early detection and reporting. Depending on the nature of the outbreak, physical distancing or staggered use of shared spaces may be implemented to manage interactions.

These settings should also have the ability to segregate persons or areas to prevent intermingling between groups during an outbreak as much as possible. This can involve zoning the facility based on risk levels, cohorting individuals with similar health status, implementing movement controls between areas, and assigning dedicated staff to specific zones. Such segregation strategies can limit the spread of infection and allow for targeted interventions.

Measures in congregate settings during the COVID-19 pandemic

Congregate settings limited the movement of individuals between different rooms, levels, or facilities to reduce the risk of intermingling. Non-essential activities and large gatherings were either postponed or held virtually, and visitors were restricted or allowed only under controlled conditions.

Section 4

The Enablers

SINGAPORE PANDEMIC PREPAREDNESS AND RESPONSE FRAMEWORK

Chapter 10: Enablers

Crucial to the effective implementation of the above measures are various enablers — resources and tools, such as technology, research, policies, and skilled personnel — that enhance a nation's capacity to prevent, anticipate, detect, and respond to disease outbreaks effectively. These enablers support public health efforts by providing the means to overcome barrier and implement evidence-based measures efficiently.

10.1 Whole-of-Government (WoG) coordination

A WoG approach is crucial for coordinating effective public health responses during an outbreak. It helps streamline decision-making processes and ensures swift and cohesive policy implementation across all sectors. By uniting the strengths of multiple government agencies, it effectively addresses the complex challenges of a public health crisis.

Singapore exemplifies this approach through its Homefront Crisis Management System (HCMS), a robust national framework that coordinates WoG planning and response during crises of national significance and impact. The Homefront Crisis Executive Group (HCEG), chaired by the Permanent Secretary for Home Affairs, comprises senior representatives from all ministries. It reports to the elected leadership for political direction. Designed to respond to national crises, the HCEG brings agencies across the Singapore Government together to guide and coordinate a coherent WoG response, factoring in an array of complex considerations.

Under the HCEG's oversight, the Crisis Management Groups (CMGs) bring together various agencies to deal with different types of incidents. The Ministry of Health (MOH) chairs the CMG for Health, providing situational updates and public health assessments, and coordinating the interagency public health response and operations.

WoG coordination in the management of ID outbreaks is further undergirded by the One Health Framework established in 2012. This framework serves as an important platform for multisectoral collaborative efforts to combat threats at the complex human-animal-environment interface. Within this structure, the inter-agency One Health Coordinating Committee (OHCC) provides strategic direction and priorities for One Health issues in Singapore. Subsequently, the inter-agency One Health Working Group (OHWG) formulates, coordinates, implements and reviews programmes aligned with these identified priorities. This One Health collaboration has led to the development of national One Health strategies such as the National Strategic Action Plan on Antimicrobial Resistance in November 2017.

10.2 Rallying the community

Rallying community support during an outbreak is key to fostering mutual responsibility and collective action, boosting government efforts. This can be achieved through engagement, public education, and widespread volunteerism. Grassroots organisations, non-governmental organisations, local community groups and volunteers play a pivotal role in supporting the public health response by (i) disseminating accurate and timely health information and combating misinformation, (ii) promoting and modelling adherence to measures, (iii) encouraging widespread vaccination uptake through peer influence and community-led campaigns, and (iv) organising volunteer-driven initiatives (e.g. distributing masks and sanitisers, particularly to vulnerable populations).

10.3 Partnering the private sector

Singapore can strengthen its outbreak response by collaborating with the private sector, which offers valuable resources, expertise, and infrastructure. In healthcare, the private sector could speed up the development and production of medical countermeasures, improve healthcare delivery and support data analytics for sense-making. Manufacturers could repurpose production lines for critical supplies like masks and ventilators. Logistic companies could help with the efficient distribution of essential goods. Additionally, businesses could also be engaged to support the smooth implementation of PHSM in public spaces and workplaces. Such collaborations not only expand the capacity and effectiveness of Singapore's public health response but also mitigate the economic impact of an outbreak by keeping businesses operational.

10.4 Legislation

Legislation provides the legal authority and structure, through the enactment of laws, to implement, regulate and enforce a comprehensive range of public health measures necessary for disease prevention and control.

The Infectious Diseases Act 1976 (IDA) is the principal legislation for the prevention and control of IDs in Singapore. The IDA empowers the Director-General of Health to implement and enforce various public health measures, such as disease notification, isolation, contact tracing and quarantine. The IDA also enables the implementation of a tiered response to address and flexibly manage outbreaks of differing severity, including the declaration of public health threats and emergencies, and the enactment of additional measures under law if required.

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Table 1: Public Health Situational Tiers

Tiers	Description
Baseline	A peacetime state in which routine disease prevention and control measures, along with public health surveillance programmes, are in place.
Outbreak Management	Where a pathogen of concern is detected, requiring urgent implementation of measures to manage disease outbreaks. These include enhanced Point of Entry (PoE) (e.g. temperature and visual screenings), and community measures (e.g. masking).
Public Health Threat	Where more stringent, widespread and longer-term control measures and restrictions are needed. These include various physical distancing measures and restrictions, up to and including a "Circuit Breaker"-like imposition.
Public Health Emergency	Where very stringent measures may be enacted, such as curfews and requisition of public health assets and manpower.

In addition, other legislations such as the Healthcare Services Act (HCSA) and the Biological Agent and Toxins Act (BATA) play vital roles in ID prevention and control, whereby:

ⓐ The HCSA regulates a broad range of healthcare services and ensures comprehensive oversight and readiness to address public health needs during an outbreak; and

ⓑ The BATA regulates the handling of biological agents and toxins and ensures safe practices to prevent the misuse and spread of such hazardous materials.

10.5 Communications

During a public health crisis, it is crucial for public communications to be reliable, clear, and robust to maintain public trust. This ensures that measures are understood, accepted, and acted upon.

One of the primary roles of communication is to build awareness and understanding of measures. This involves educating the public about the measures, promoting adherence, and countering disinformation and misinformation. Clear, timely, and consistent messaging is essential for the successful implementation of measures and for uniting people towards better health outcomes. As measures may require individuals to change behaviours, messaging must be tailored to resonate with different demographic groups, addressing cultural, social, and psychological factors.

Communication is not just about disseminating information but also listening and addressing the concerns raised by the public and stakeholders involved in the implementation of the measures. Platforms for two-way engagements, such as public forums, surveys, or social media, could be used to address misconceptions and adapt measures to community needs.

When a disease outbreak occurs, the government will provide key information on the disease characteristics and specific actionable advice, such as how the public can best protect themselves, based on the prevailing scientific evidence and risk assessments. Communications will be adapted to reflect the changing situation and response strategies, ensuring relevance to each phase of the outbreak. A wide range of media channels, both mainstream media such as television, radio, and newspaper, as well as digital platforms such as social media, messaging apps, and community surveys, will be employed to reach diverse audiences effectively, address misinformation, and promote two-way engagements.

In the early stages of an outbreak, even when information may be scarce, the government communicating clearly and regularly keeps the public posted on the latest developments. Transparent and open communications ensure the public relies on official sources for the latest information.

10.6 International engagements

As a small country with an open economy, Singapore's resilience against global health threats is bolstered by working closely with our regional and international counterparts, and health organisations, to build capacity and strengthen our collective defence. This includes the Association of Southeast Asian Nations and the World Health Organization (WHO). International engagement provides access to a global network of knowledge and resources to detect and respond to health crises, while also allowing us to contribute our expertise to the world stage.

Technical cooperation amongst countries is crucial in combating ID spread across borders, which affects multiple countries simultaneously. This collaboration can include the timely exchange of information such as surveillance and risk assessment data, best practices in outbreak prevention and control, and sharing of viral genomic sequences.

10.7 Research and development (R&D)

Research and development (R&D) is key to improving how outbreaks are managed by improving disease understanding, enhancing disease detection and creating new medical countermeasures. These innovations are vital in managing disease outbreaks, particularly with a novel infectious disease (ID), where established tests and medical countermeasures may not exist. R&D also supports the expansion of scientific knowledge in critical fields such as epidemiology, microbial and viral genomics, and ID modelling. This expansion of knowledge is facilitated through international collaboration conducted on bilateral or multilateral platforms, fostering a global exchange of knowledge and expertise and enhancing our collective ability to respond to emerging public health threats.

10.8 Knowledge management and continuous learning

As scientific understanding evolves and new threats emerge, a culture of learning and adaptation is important to strengthen the preparedness and response capabilities. This involves both systematic knowledge management to preserve institutional expertise, alongside continuous learning to remain current with scientific developments and implement emerging best practices in pandemic prevention and control.

Effective knowledge management integrates the systematic capture, organisation, and sharing of critical information and practical insights across the public health system. This creates institutional memory that can be readily drawn upon to support effective decision-making during outbreak responses and inform future responses.

Continuous learning focuses on improving existing capabilities through lessons derived from past ID outbreaks and developing new capabilities to address identified skill gaps in response to emerging threats and technological advances. It involves assessment mechanisms to evaluate competency levels and identify gaps requiring attention, followed by a structured improvement implementation process that transforms identified needs into concrete actions.

Examples of R&D initiatives in Singapore

The Programme for Research in Epidemic Preparedness and Response (PREPARE) aims to strengthen Singapore's key research capabilities and translational platforms to develop tools, methods and products for early detection and response to ID threats. This includes strengthening data infrastructure, analytics and behavioural science for public health crises, improving resilience in diagnostics, therapeutics, and vaccines, and fostering a strong regional research collaboration network to tackle epidemics and support multicentre clinical trials.

To support continuous learning and strengthen knowledge retention, organisations should:

- Formally document outbreak events including epidemiological data, public health strategies, operational challenges and response outcomes;
- Perform after-action reviews and incorporate findings into future planning;
- Implement regular tabletop exercises and simulation drills to identify potential gaps in pandemic response and review overall preparedness approach; and
- Conduct regular training programmes to maintain workforce competency in ID outbreak and pandemic management.

These activities create a dynamic cycle of continuous improvement, which can be further enriched by cross-institutional collaboration which facilitates the exchange of expertise and best practices, preventing the siloing of valuable insights and experience.

10.9 Fiscal policies

In an outbreak, fiscal policies support the implementation of PHSM, and ramping up of medical countermeasures and healthcare services by providing the necessary funding and incentives to ensure their effectiveness. Financing is also needed as part of preparedness, through strengthening national capacities for outbreak prevention, detection and response. An effective outbreak response could require funding for:

- Healthcare infrastructure and resources, such as manpower, testing facilities and treatment centres to handle the surge in demand during outbreaks;
- Vaccines, therapeutics, and other essential medical supplies, for disease prevention and care;
- R&D of diagnostics, vaccines and therapeutics, to develop early solutions to identify, prevent, control, and treat the disease;
- Social support programmes, such as financial assistance schemes, to help those economically impacted by the outbreak; and
- Public health education campaigns to increase public awareness of the outbreak, including the necessary preventive measures.

10.10 Technology

Technology complements the overall outbreak responses by facilitating prompt, agile, efficient, and data-driven implementation of public health measures. Integrable digital technology solutions for crisis management may include telemedicine as an alternative source for healthcare provision to alleviate pressure on the healthcare system, and digital contact tracing applications to complement manual contact tracing for outbreak control. The institutionalisation of technology necessitates robust cybersecurity safeguards and interoperable systems with seamless data flow to ensure efficient operationalisation of public health measures.

Singapore must remain flexible in adopting new technologies to quickly adapt to health crises. Innovation would need to be balanced with ethical considerations to keep technology accessible and privacy-respecting, whilst serving the greater public good.

Fiscal support measures during COVID-19 pandemic

During the COVID-19 pandemic, the Singapore Government introduced multiple stimulus packages, collectively known as the "Unity", "Resilience", "Solidarity", and "Fortitude" budgets. These measures included direct cash payouts to citizens, wage subsidies for businesses to retain workers, tax rebates, and increased healthcare spending. Support was targeted at vulnerable sectors such as aviation, tourism, and food services, while also providing broader assistance to households and businesses across the board. These fiscal interventions were designed to protect jobs, support businesses, and strengthen economic and social resilience in the face of the pandemic's challenges.

10.11 Resources

Resources are fundamental to the effective management of outbreaks as they form the backbone of a robust and resilient response and enable systems to withstand the pressures of an outbreak. These resources include (non-exhaustive):

- ⓐ **Facilities** such as (i) healthcare facilities to provide necessary healthcare services and (ii) non-healthcare facilities to support public health measures including isolation of infected cases, quarantine of close contacts, testing, and vaccination.
- ⓑ **Supplies**, including essential medical supplies, diagnostic tools, personal protective equipment, vaccines, and pharmaceuticals, which are essential for managing disease outbreaks.
- ⓒ **Manpower**, which is vital for delivering healthcare services, implementing public health measures, and operating various support systems during an outbreak.

10.12 Environmental/ social planning

Environmental and social planning are crucial for implementing PHSM and medical countermeasures during disease outbreaks. Environmental planning involves the design and creation of infrastructures that are pandemic-ready, such as flexible public spaces to allow safe distancing, multi-purpose infrastructures that can convert flexibly, or use of contactless features to reduce transmission. Social planning addresses and minimises the social impact of measures, by ensuring vulnerable groups have access to healthcare and essential services through community support. This can be done with the social service sector rallying their networks of partners and volunteers to address the increased needs on the ground, through initiatives such as essential aid and food deliveries, as well as counselling sessions. Pandemics and public health crises can have an impact on the mental well-being of the population, particularly for vulnerable groups like seniors and adolescents. Caring for the needs of the community during a crisis requires WoG support, with a strong network of partners, including social service organisations, community groups, and volunteers.

Conclusion

Singapore has broadened to include a disease-agnostic approach using its Pandemic Preparedness and Response Framework. By focusing on building adaptable and scalable systems during peacetime rather than only focusing on disease-specific plans, Singapore is better positioned to respond to a wide range of ID threats, both known and unknown. This framework underscores the importance of agility, integration, and coordination across multiple sectors, as well as an informed and engaged civil society, in ensuring that the nation can quickly mobilise and adapt to new challenges as they arise.

The framework's emphasis on saving lives and protecting livelihoods through a balanced application of PHSMs, along with medical countermeasures, reflects a comprehensive approach to safeguarding the population's health while maintaining social and economic stability. The inclusion of enablers such as technology, research, and skilled personnel further strengthens Singapore's capacity to implement these measures effectively and efficiently.

This proactive and comprehensive approach underscores Singapore's commitment to maintaining resilience and preparedness in an ever-changing global health landscape.

Notes

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