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Editorial

Pandemic Preparedness: Learning from COVID-19

Future pandemics are a certainty, although their timing, aetiology and severity are unpredictable. COVID-19 caused over 28 million excess deaths globally, with an estimated US$ 15.8 trillion impact to global health.[1] Future pandemics may even be more severe than COVID-19, as illustrated by the 1918 influenza pandemic. Pandemics emerge when animal pathogens spillover to humans and establish sustained transmission within human populations. Anthropogenic activities (international travel and trade, intensive livestock industry, wild-game animal trade for food, fur and pets, deforestation and climate change) are increasing the probability of these spillovers, and thus, increasing risk of pandemics. Much attention is currently rightly being placed on countermeasures for pandemic response (vaccines, antivirals, diagnostics) but there is less attention to reducing risk of spillovers ("prevention at source").[2] Intensive animal husbandry practices which involve moving livestock large distances to achieve maximal production efficiency or for marketing, live poultry markets, live wild-animal trade for food, pets and fur provide well established interfaces across which multiple pathogens have emerged to cause epidemics and pandemics.

Studies at the animal-human interface carried out in a "One Health" approach are needed to identify critical intervention points where spillover risks can be generically reduced. As an example, scientific evidence now suggests that COVID-19 emerged via wild or farmed game animals such as racoon dogs sold at the Huanan "sea-food" market in Wuhan, very similar to the pathway through which SARS-CoV-1 emerged in 2002/3.[3,4] Surveillance of such game animal markets has demonstrated the presence of numerous known and previously unknown viruses, some with pandemic potential.[5] This highlights the importance of regulating and controlling this wild-animal trade, which has demonstrable adverse impacts on zoonotic threats as well as on biodiversity and species-extinction.[2]

The delayed introduction of critically urgent control measures (e.g. enforcing compulsory testing of bulk-milk samples for surveillance and movement restrictions of dairy cattle for prevention of spread), possibly as result of the reluctance of the US dairy industry, allowed a single spillover of highly pathogenic avian influenza A (H5N1) from wild birds to dairy cows in a single Texas dairy herd to spread (as of 10 Feb 2025) to 959 dairy herds in 16 states of USA, resulting in 40 zoonotic transmissions so far.[6]

Table 1: Early assessments that need to be made in a novel infectious disease epidemic

1.	Early recognition of a novel outbreak
2.	Is there human-to-human transmission?
3.	Is there asymptomatic infection and transmission and transmission kinetics?
4.	Modes of transmission?
5.	Disease severity?
6.	Is the outbreak containable and how aggressive should containment actions be? Balancing negative impacts of containment measures with successful containment.

In parallel, we need to enhance our capacity to respond quickly and effectively to future epidemics and pandemics. Pandemic response plans with

a "whole-of government" response structure needs to be planned and prepared in advance, during the interpandemic period. Similarly, establishing public trust and good communication strategies are critical competencies in good pandemic response.[7] Key questions that need to be rapidly assessed in the early stage of a pandemic are listed in Table 1.

Clinical and epidemiological alertness to unusual disease patterns is often the earliest sign of a novel pathogen and disease, as illustrated by the recognition of the West Nile virus in New York, USA in 1999.[8] Establishing molecular diagnostics early in an outbreak depends on capacity to implement "in-house" PCR tests in a reliable and scalable manner (PCR "kits" will not be available for months), being able to mobilise University or Commercial laboratory partners to scale testing capacity and ability to institute quality control in such diverse testing venues. Mina at al highlighted that rapid point of care diagnostics can be very effective at containment of transmission even though they may not be as "sensitive" as PCR methods, because they are sufficiently sensitive at detecting patients with high viral load who are those most able to transmit infection in the community.[9] Aggressive laboratory and epidemiological investigation of case-clusters which reveal evidence of human-to-human transmission[10], asymptomatic infection and viral load kinetics in patient-cohorts can reveal transmission dynamics.[11]

Ease of containment of a novel disease outbreak depends on a) the reproduction number (R) of the outbreak as well as the proportion of transmissions that occur prior to or very early after onset of symptoms[12], and b) the asymptomatic or mild fraction of cases (i.e. the invisible iceberg of infection). Accurate assessments of disease severity require sero-epidemiological studies to ascertain the asymptomatic fraction of infection. Fatality rates based on laboratory confirmed cases seeking hospital care often grossly over-estimate disease severity and sero-epidemiology provides more reliable assessments.[13] Wastewater surveillance can provide unbiased assessment of pathogen circulation in the community.[14]

Smart-epidemiology needed for epidemic control needs to integrate multiple data sources including confirmed case counts, syndromic surveillance, outbreak investigations, sero-epidemiological data, waste-water surveillance, hospitalised case data and genomic surveillance.[15]

The experience of COVID-19 demonstrated the effectiveness of non-pharmaceutical interventions (masks, social distancing, ventilation) in reducing transmission of an airborne pathogen.[16,17] A recent WHO "Pathogens Prioritization" framework has reviewed 29 pathogen families and identified priority pathogen families and prototype pathogens for pre-pandemic vaccine, antimicrobial and diagnostic development.[18] It is important to recognize that even with such preparation, vaccines are unlikely to be available to combat the first (or even second or third) waves of a future pandemic. Better equity of vaccine and antiviral supply to low and middle-income countries is needed.[7] Equally, capacity for evidence-based vaccine roll-out to high-risk groups needs to be in place, together with effective communication to combat misinformation, which requires sociological and anthropological perspectives.[19]

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