Cambridge Risk Framework

Profile of a Macro-Catastrophe Threat Type

Disease Outbreak

Human Pandemic

Centre for
Risk Studies

UNIVERSITY OF CAMBRIDGE
Judge Business School

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Abstract

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1 Overview of the Threat

1.1 Definition

Human pandemics are infectious disease outbreaks that spread internationally and cause death and illness in human populations, including influenza pandemics, emerging infectious diseases and re-emergent disease epidemics.

1.2 Overview

Disease epidemics have been the causes of some of the worst socio-economic shocks throughout human history. At its most extreme, large parts of 14th Century Europe lost a third of its population to a terrible plague. But disease impacts are not just an ancient historical anomaly – this current generation has had to deal with the impact of HIV/AIDS – a previously unknown disease that medical science could not combat and that has killed 30 million people, many of them wealthy, educated people with access to the best healthcare available in the world.

Nature and mankind have

Infectious diseases are the leading cause of death worldwide, accounting for a quarter to a third of all mortality. In most industrialized countries, infectious disease ranks after cancer and heart disease as a primary cause of mortality. Despite developments in pharmaceuticals, infectious disease rates are rising due to changes in human behavior, larger and denser cities, increased trade and travel, inappropriate use of antibiotic drugs, and the emersion of new and re-emerging pathogens.

Twenty known diseases have recently re-emerged or spread geographically. These new outbreaks are of more virulent and drug-resistant forms. At least 30 unknown disease agents for which no cures are available have been identified in human populations in the last few decades, including HIV, Ebola, and hepatitis C and E. Infectious disease outbreaks pose a major threat both nationally and internationally. They easily cross borders and can threaten economic and regional stability as has been demonstrated historically by influenza and SARS epidemics.

1.3 Influenza

A notable source of variability in the annual mortality rate of industrialized countries is influenza. The main complication of the influenza virus is that of pneumonia which accounts for much of the morbidity and mortality. Secondary bacterial pneumonia associated with influenza is most common among the chronically ill, who are more susceptible to this complication. Occasionally flu rates can reach pandemic proportions across the population.

Influenza is a contagious disease caused by an RNA virus. It most often affects the upper airway and lungs of birds and some mammals. It causes seasonal epidemics globally and is a leading cause of infectious disease-related deaths in most countries around the world. In non-pandemic years influenza typically kills hundreds of thousands of people worldwide. The highest rates of mortality are in the elderly followed by children and There have been three influenza pandemics in the 20th century, in 1918, 1957, and 1968, each the result of a major genetic change in the virus.

Influenza's effects are much more severe than those of the common cold. Typically, recovery takes about 10 days. Each year 10% to 20% of United States residents are infected with an influenza virus. An average of about 36,000 people per year in the United States die from influenza, and around 200,000 are admitted to the hospital for an average of 5.5 days (Thompson et al., 2004). Influenza is most often deadly in the weak, old, or chronically ill. The most common cause of death is secondary complications such as bacterial pneumonia. According to estimates by the World Health Organization, between 5 and 15% of the world's population contracts the flu each year resulting in between 250,000 and 500,000 deaths (WHO, 2006). Healthy people can be affected, and serious complications from influenza can arise at any age. People age 65 years and older, people of any age with chronic medical conditions, and very young children are most likely to have complications from influenza. Pneumonia, bronchitis, sinus, and ear infections are four examples of such complications.

1.3.1 Mutation

Viruses are exceptionally adaptable organisms. They are constantly undergoing genetic change resulting in new strains of disease that are immune to standard treatments or that have more effective transmission. Viruses with high mutation rates include HIV, influenza, hepatitis C and polio. Mutation processes and rates of mutation are the subject of extensive medical research. The process of virus mutation may include jumping animal species or causing a greater threat to humans due to an increased degree of contagion and/or lethality.

Antigenic variation is the process by which an influenza virus mutates to evade the immune systems. Antigenic drift constantly results in a new strains of influenza viruses. Approximately, every thirty years, a more serious antigenic shift occurs involving an exchange of gene segments between influenza viruses. In these cases, a significant proportion of adult and children protective antibody levels are absent, and a global pandemic results. Epidemiological models can replicate general patterns of sickness and mortality.

1.3.2 Antigenic drift

Antigenic drift type mutation involves natural selection and over time the virus evolves into a new strain with novel characteristics such as drug-resistance or increased transmissibility and/or severity. This process typically involves trade-offs and the characteristics of the resulting virus are rarely significantly different than existing strains. Rapid rates of evolutionary drift is why humans will never cure or be immune to influenza and why flu vaccines will only be effective against a limited number of strains and only for a short period of time.

1.3.3 Antigenic Shift

The less common, but potentially more dangerous type of viral mutation is antigenic shift. This process can occur by a virus jumping directly between species, such as from bird to human, by the use of an intermediate host such as a swine, or by reassortment. In reassortment viruses are able to bypass the natural selection process by combining the genetic material from two completely separate viruses. This instantaneous process can result in a new virus or a new strain with some characteristics from both of the parent viruses.

The main viral reservoirs are animals, such as swine or birds. When these animals come into close contact with human populations the virus can adapt to infect human populations. In June 2001, and again in May 2002, a total of 4 million chickens were destroyed in Hong Kong as a precaution against the global spread of a new strain of avian influenza. Beyond China, international surveillance is headed by the World Health Organization (WHO), which has developed an Internet application linking the global network of influenza centers (FluNet). A major objective of FluNet is the selection of strains included each year in influenza vaccines as well as to track new influenza strains before they become established in human populations.

1.3.4 Seasonal Variation

Influenza most often reaches peak incidence in winter, because of this there are two flu seasons globally one in the Northern and one it the Southern Hemisphere.

The overwhelming majority of influenza outbreaks in the Northern Hemisphere peak in mid-winter, but this is not universal. Pandemic influenza could potentially peak anytime of year. In the case of 1918 pandemic the peak was during late spring and summer globally. In the United States the incidence peaked in October. The reasons behind the seasonality of flu are not completely understood. Some possible explanations include that people are indoors and in closer contact during the winter and the virus may survive better outside the body in colder temperatures.

1.4 Vaccine

Influenza infection causes a strong immune response, so one person will never be infected with the same strain of the virus twice. However, antigenic drift occurs extremely quickly so that new strains arise and the population is susceptible to a new strain of infection. Immunization with flu vaccines is moderately helpful in reducing the size and severity of epidemics. Vaccines incorporate inactivated virus particles or purified hemagglutinin, a surface protein on the influenza virus. Each year a decision is made from surveillance data on which strains should be incorporated into the vaccine. Once a vaccine is administered it takes time for protective level of antibodies to build up. The length of time needed to build up antibodies makes is so that once a virus is circulating in a population vaccine is not particularly helpful in controlling an epidemic.

Vaccine efficacy is less than 100%, and it is possible to be vaccinated and still get influenza. In addition, the seasonal vaccine typically includes only 3 strains of influenza and unless they match the circulating strains the vaccine will not be effective at preventing infection. Vaccines can provide partial coverage and may help reduce mortality and infection severity even if they do not prevent it. Since, it typically takes 6 months to produce a flu vaccine in the event of a pandemic; vaccines providing partial immunity may be a key component in preventing mortality.

1.5 Pharmaceuticals

1.5.1 Antibiotics

Antibiotics are of no value in preventing transmission or controlling the flu virus. However, they are responsible for limiting mortality in flu epidemics. A common cause of flu-related death is secondary bacterial infections, such as pneumonia. Antibiotics are important in reducing the severity of secondary infections and are responsible for the reductions in mortality in the 1957 and 1968 pandemics.

1.5.2 Amantadine and Rimantadine

These drugs are antivirals that interfere with the production of the virus. They inhibit one of the proteins needed for viral reproduction. They work against type A influenza strains and resistance to these drugs evolves quickly. Once resistance is acquired the drugs are useless, so it is unlikely that these will be helpful in combating an emerging epidemic.

1.5.3 Zanamivir (Relenza®) and Oseltamivir (Tamiflu®)

These drugs affect an enzyme that inhibits the release and spread of virions. These drugs may reduce symptoms such as weakness, headache, fever, cough, and sore throat by 1 to 3 days. There is an ongoing debate on their effectiveness in preventing influenza infection. Many countries are relying on these drugs to reduce transmission and infection in those exposed. However, the efficacy of this approach remains unknown as does the ability of the influenza virus to develop resistance to these drugs.

1.5.4 New Drugs?

Anti-viral drugs are significantly harder to produce than antibacterial drugs because the virus life cycle is dependent on the host. It is quite easy to kill most viruses; however these methods will also kill the host cells as well. Research is currently being focused on developing drugs that target molecular machinery unique to the virus. The more knowledge gained about the molecular structure of viruses, the closer we come to developing a successful drug. The ever-changing characteristics of viruses make this a monumentally difficult task and it is doubtful we will have a viral miracle drug in the near future.

2 Historical Pandemics

Earliest reports of influenza epidemics date back to Hippocrates around 412 BC. In the Middle Ages infectious disease epidemics were common many of which were probably influenza. A particularly severe pandemic struck Africa, Europe, and the Americas in 1580. Death rates were high and it killed over 10 percent of the population of Rome and decimated many Spanish cities (Beveridge 1978).

In the past 3 centuries ten pandemics have been recorded at intervals of 10 to 49 years with an average of 24 years. During the 17th century, localized epidemics were reported, and in the 18th century at least three pandemics occurred in 1729, 1732, and 1781. Three influenza pandemics also occurred during the 19th century in 1830, 1833, and 1889. The 1889 pandemic known as the Russian Flu began in Russia and spread rapidly throughout Europe. It reached North America in December 1889 and spread to Latin America and Asia in February 1890. It is estimated that around 1 million people died in this pandemic.

In between pandemics, influenza epidemics cause an average of 20,000 excess deaths annually in the U.S., which is only about 10% of the number of deaths from all forms of respiratory disease. The death toll in pandemics is far greater. There have been three pandemics in the last century, in 1918, 1957, and 1968. Before then, there was a pandemic in 1889. Of these, the most disastrous was the global 1918 pandemic, which was more lethal than the First World War itself. Around 700,000 Americans died in the 1918 pandemic, which was 0.67% of the 105 million population at that time. By comparison, the US excess death tolls from the 1957 and 1968 pandemics were about 70,000 and 40,000, which were 0.04% and 0.02% of their respective populations. An excess death toll of 200,000 people would represent 0.07% of today's population, one tenth of the ratio of the population of the 1918 pandemic, but greater than those of 1957 and 1968.

3 Scenario identification

The scenario is selected from the event set of the Infectious Disease Model (IDM) produced by Risk Management Solutions. The RMS IDM is a commercial model licensed by life insurance companies for use in risk management of life insurance portfolios. The model consists of several thousands of simulated synthetic scenarios of pandemics, with stochastic assessments of the variables that could occur, to deliver a probabilistic view of the risk spectrum of pandemics that could occur.

The RMS IDM is designed to provide a probabilistic view of the losses that could result from infectious disease pandemics. RMS uses the latest scientific understanding from the disciplines of virology, epidemiology, and mathematical biology, and has built two distinct event sets that allow for capture of characteristics of both influenza and non-influenza emerging infectious disease pandemics. The influenza event set, consisting of 2,016 scenarios, and the infectious disease event set, consisting of 2,520 scenarios, represent the potential range of characteristics of a pandemic and likelihood of occurrence. Mortality rates per five-year age cohort are produced for each scenario event. The RMS Infectious Disease Model is a global pandemic model and assumes global occurrence of disease with loss for every scenario event in all modeled portfolios. The explicit modeling of emerging infectious diseases other than influenza represents a significant refinement of the tail risk; while typically less frequent than influenza pandemics, these events are usually more severe. Although influenza is a subset of emerging infectious diseases, the influenza virus has distinct characteristics and an increased frequency that can be best represented with a split modeling approach. The emerging infectious disease and influenza event set should be combined to give a holistic representation of representation of the risk from infectious disease.

RMS models the spread of the infection through the population using Susceptible, Infected, Recovered (SIR) modeling, a well-established technique used by epidemiologists to accurately describe the spread of diseases. The SIR model computes the theoretical number of people infected with an infectious disease in a closed population over time.

RMS uses a scale that includes both transmissibility and virulence when determining pathogen severity classification and modeling losses. In the IDM, there are 42 combinations of transmissibility (6 levels) and virulence (7 levels). Each combination is associated with a different starting mortality rate. In addition, there is variation of outcome in any given pathogen severity level, and the IDM takes into account the variability of intervention measures, vaccine availability, etc., when assessing final mortality rate for a particular event.

The transmissibility and virulence of an infectious disease pathogen are key parameters in modeling the scale of the overall loss of life during a pandemic event. The transmissibility (or infectiousness) represents the speed at which a pandemic will spread within a population and the total number of people that will be infected. Transmissibility depends on contact rates, duration of infectiousness, and likelihood of contacts becoming infected. The virulence of a pathogen is measured in terms of its case-fatality rate (CFR), and determines how fatal the illness is. Pathogens can affect their hosts in different ways according to their genetic structure, and vary considerably in their virulence. For example, seasonal flu has a low CFR (around one person per 1,000 cases), but even so, around 40,000 Americans die of seasonal flu each year. The 1918 virus had a CFR of over twenty times higher than seasonal flu.

3.1 Key features

There are two key parameters of an infectious disease pathogen, like influenza. These are:

a) Infectiousness: how fast it spreads and what % of the population it ultimately infects

b) Virulence: how severely it makes people sick, and how many infected people die as a result.

These two parameters are not independent: A disease that is very virulent kills off its host and scares people into reducing their contact rate, so the number of people that are infected is reduced. Viruses tend to sacrifice virulence for infectiousness as they mutate to maximize their evolutionary success

The 1-in-100 scenario could be caused by many combinations of infectiousness and virulence.

We have selected a specific scenario for use in the stress testing by looking at the return period of ***infectiousness***, and picking an appropriate level of virulence that results.

The 1-in-100 level of infectiousness results in around 43% of the world's population being infected. This is different from country to country and in different regions. It likely to be higher and more virulent in the initial outbreak region but to lose virulence as it spreads, so that the worldwide virulence is considerably lower than its initial phase.

4 Developing the Scenario

Three different types of scenarios are considered:

4.1 Virulent Disease – Low Infection Rate

This could potentially impact at around 1-in-100; e.g. SARS. This would kill a high percentage of those infected, but would have a limited spread. Fear of being infected shuts down commercial activities. Direct impacts would be low, but it could be highly disruptive

4.2 Highly Infectious Disease – Moderate Virulence

For example an influenza pandemic that infects a high % of population. Absenteeism and scale of medical treatment required is the major societal issue. It would touch many areas of commercial activity and potentially multiple lines of insurance coverages,

4.3 New variant of contagious pathogen

This could be a new variant of contagious pathogen for which medical science has no initial treatment, for example Laboratory gain-of-function H5N1, AIDS, or a haemorrhagic virus. This has extremely low probability (well beyond 1-in-100). It could combine high virulence with high infection. It could also have additional features that make response more complex (e.g. lengthy incubation period, asymptomatic spread, age-significant response).

4.4 Selected Scenario

We have chosen to develop the stress test scenario for Highly Infectious Disease – Moderate Virulence

We believe this will give the best stress test at the 1-in-100 level for multiple lines of insurance business. If this proves useful, it will be possible in future stages of the project to develop additional scenarios that explore the characteristics of the other scenario types.

4.4.1 Pandemic Scenario Stages

A. Outbreak

Evidence emerges that a new pathogen has emerged, but the implications are not yet apparent. Impact is regional – the location of the outbreak and industries associated with the outbreak are directly impacted.

B. International Spread

Period of chaotic uncertainty as the disease starts to spread but little is known about the pathogen or exactly what is occurring. The world is caught between the need for preparedness and concern for over-reaction.

C. Pandemic response

The characteristics of the pathogen become clearer. All countries are now experiencing the full impact of the infection spreading rapidly through their populations. There is no vaccine yet available but the world has to manage to try to minimize the impacts of the pandemic and slow up the spread until a vaccine is developed.

D. Vaccination phase

The knowledge that a vaccine has been developed brings hope and optimism, but there are frustrations and public impatience in the time taken to obtain large quantities of vaccine and implement a vaccination programme. The disease continues to spread for some time and the worst of the impacts may be occurring at the same time.

E. Post-peak tail-off

Once the wave of illness has peaked, the expectation may be that the pandemic is conquered, but the peak marks roughly the half-way stage in the pandemic. There may be an even longer period of continued illness spread, social disruption, and frustratingly slow progress in returning to pre-pandemic life.

F. Possible resurgent waves

Even after the pandemic has apparently passed, there will be resurgent waves of infection, possibly due to new strains of the virus as it mutates. The virus is likely to cause a heavy increase in the next seasonal flu. Each of these may cause alarm and public despondency.

4.5 Main variants

4.5.1 Vaccine availability and vaccination programme

a) Average or expected (Similar to previous experience and based on current manufacturing capacity, expected ordering process, average efficacy of vaccines, typical pace of vaccination programme)

b) Worse than expected: (Long delay in developing vaccine and difficulties in manufacturing, slow vaccination execution, poor vaccine efficacy)

c) Better than expected (new processes of cell-culture introduced that speeds manufacturing outputs, faster vaccination, good efficacy)

4.5.2 Quality of government response

i. As expected (defined in Government-published WHO Pandemic Preparedness Plan)

ii. Poor (worse than expectations – slow response, ineffective actions, poor public response)

iii. Better than expected (more resources, more highly prioritized, more successful in public response etc.)

5 Scenario Specification

A new variant of influenza virus is identified in Brazilian poultry farmers. It quickly spreads from Brazil to infect populations worldwide.

The virus is highly infectious – it has an initial reproductive index (R0) of 2.25. It ultimately infects 43% of the world's population.

The virulence of the virus appears high initially, but over time the average case fatality rate is relatively moderate – less than 0.4% of people infected die from it.

The Sao Paulo Virus Pandemic: A fictional example of a severe human disease outbreak

A. Outbreak

Clusters of unusual deaths and severe illness in otherwise healthy young men in suburbs of Sao Paulo are recorded by Anvisa, the National Health Surveillance Agency of Brazil. The casualties are mainly workers in poultry farms. Laboratory tests identify that they are infected with a new variant of influenza virus, H7N9. The new virus is circulating in the battery chicken population but has jumped species to infect the farm workers. The virus is similar to variants of H7N9 found in birds in China, and officials suspect that it may have come to Brazil through international imports of poultry.

Some of the deaths are occurring in friends and family of the poultry farm workers, demonstrating that that the virus has mutated and undergone an antigenic shift, and is now being transmitted from human to human. There is no vaccine available for H7N9 but the disease responds well to anti-viral treatment, if administered in the first 48 hours, before the infection is too far advanced.

Over a 10 day period there are over 100 deaths. Most of the deaths are in teenagers and young adults. The outbreak is quickly picked up by the international media who dub this the ‘Killer Sao Paulo Virus’. Public health officials are trying to track all the known contacts of the people known to be infected – over 2,000 people are put into quarantine. The death count suggests that the virulence of the virus could be disturbingly high. Case Fatality Rate estimates are wildly variable, as nobody knows quite how many people are actually infected. A specialist team from the World Health Organization arrives in Brazil to investigate. A local doctor tells reporters that he estimates that “10% of people who catch the virus die”.

The media reports are alarmist, with headlines such as ‘Deadly pandemic on the way’. A WHO spokesman is quick to disparage these reports and warn against unnecessary reactions. However, international stock markets are affected by the news, with a particular impact on Latin American currencies and regional markets. Stock prices fall for international companies involved in exports to Brazil, particularly machinery and public transport suppliers, and chemical providers.

Measures taken to prevent any further spread of the virus include the large scale destruction of farmed chicken populations throughout Brazil and Latin America. Exports of livestock from China and South East Asia are suspended. Poultry farms in many countries are subjected to testing programmes, and pockets of H7N9-infected chickens are found in many countries, leading to widespread preventative culls of poultry populations. Many farmers and meat producers are affected. There are shortages of chicken meat on the international market.

Foreign offices of many countries put out official advice to avoid unnecessary travel to Brazil. An executive of a US company on a business trip is hospitalized in Brazil with Sao Paulo Virus. He sues his company for not having prevented travel to the affected region. Many companies institute compulsory no-travel policies.

WHO declares ‘Alert’ level, the second tier on its four-phase pandemic risk scale and institutes an Emergency Committee to advise the Director General on preparation and response.

B. International Spread

Cases of Sao Paulo Virus start to be recorded in several other countries, particularly those with strong air traffic connections to Brazil. United States and Southern Europe see clusters of new cases. Standard procedure is for contact tracing and containment: in each case, with people that the infected person has come into contact with being traced, placed in quarantine and given anti-viral drugs.

Laboratories become overloaded with requests to test suspected cases. They quickly face a backlog of several weeks, meaning that officials cannot assess the extent of infection in the population. Eventually public health labs give up on conducting tests, and resort to only testing sample sub-sets.

Deaths in countries across the world start occurring about two weeks after the index cases in each country. Traditional and social media focus on recording the incidence of people who are infected and highlight the deaths. Personal knowledge of someone infected increases the perception of many in the general public, and social media help to personalise the pandemic. Fear is rapidly spreading that there is a deadly disease circulating for which there is no medical treatment. People advocate withdrawing children from school and staying away from workplaces or other social contact. Public health officials and political leaders in each country try to respond to these fears with public pronouncements and reassurance. Politicians warn of the economic impact of a 'pandemic' false alarm. The WHO urges caution and resists declaring a global pandemic.

Many people from North American and Europe stop travelling, particularly to Latin America. The airline industry sees major drop-off in demand. Latin American tourism and international tourism generally is affected. Major sporting and entertainment events throughout the region are cancelled, including the FIFA Soccer World Cup scheduled for the summer of 2014.

Public health officials are still grappling with understanding the characteristics of the virus, but identify that it has a high infectiousness index (R_0). If it is not possible to contain the spread of the disease, it will rapidly spread globally. This is a period of major uncertainty, with a lot of commentary, opinion, and news coverage, but few facts.

Businesses grapple with the impacts on their operations of public concern and some levels of employee absenteeism.

A random sample surveillance test for H7N9 antibodies in the human population of Sao Paulo suggests that infection rates have been much higher than previously estimated. This means that there is likely to be significant numbers of people with mild infections that are spreading it to others. The spread is not likely to be containable by contact-tracing people with severe symptoms. However, this also means that the virus is less deadly than originally feared – the known death count is the tip of an iceberg of much broader spectrum of illness caused by the infection.

Many countries start ordering anti-viral drugs to top up their stockpiles, but demand exceeds supply; Roche auctions its Tamiflu production capacity.

C. Pandemic Response

The spread of cases of Sao Paulo Virus is now evident within multiple continents, with caseloads increasing week by week. General practitioners and health clinics are swamped with people with suspected flu symptoms and people worried they may be infected.

After increasing political pressure and detailed review, WHO finally declares a global pandemic, and upgrades its pandemic alert to Phase 3 'Pandemic'. This requires governments worldwide to implement their pandemic preparedness plans. Every country has its own plan, but each is a blend of increasing public healthcare resources and prioritising pandemic treatment, a pharmaceutical strategy of making stockpiles of drugs available to frontline healthcare services, and non-pharmaceutical strategies of reducing contact rates in the general public through actions.

Typically, governments cancel non-emergency hospital admittance, and set up layered healthcare provision, including increased clinic and GP consultation capability, streamlined drug prescription processes, emergency hospital wards and improvised overflow bed facilities, prioritised critical care facilities, ventilators, and emergency equipment. Even so, the demand for medical treatment is typically exceeded, and care is triaged, with prioritization for life-threatened cases.

In many countries their non-pharmaceutical strategies involve closing schools, suspending public gatherings, closing restaurants, theatres, sports stadiums and other activities. There is no official advice provided about suspending workplace activity. Public transport continues, but trains and buses timetables are impacted by a reduced workforce.

Companies find that a growing number of their employees are off sick each week. They struggle to maintain business operations. Many companies institute rules for operation during a pandemic, including allowing work-at-home and remote access, daily sterilization of work surfaces, reducing the size of in-person meetings, and exposure of staff to contact with the general public. Even so, many are affected by absenteeism from staff who are sick, nursing sick family members, or unwilling to come to work. Management suspects that many reported cases of the virus are excuses for no-shows. Many instigate reduced productivity working. Some companies close down their offices. Workers asked to continue work and who subsequently get sick bring claims against management for exposing them to an unsafe workspace.

Essential services, utility provision, power, water, trucking delivery, and other commercial activities are impacted by periods of service failures, caused by the absenteeism of skilled or essential operatives. Countries face power blackouts, delivery shortfalls, and shortages.

There is panic-buying of over-the-counter medical supplies, food, petrol, and general supplies. Restocking sold-out supermarkets, petrol stations, pharmacies, etc. becomes a problem with high absenteeism in truck drivers and delivery personnel. The army is drafted in to maintain essential supplies and services.

The increasing case loads now make it possible to measure the Case Fatality Rate with some confidence. CFR is averaging less than 0.5% - lower in countries applying rapid anti-viral treatment.

Towards the end of this phase a leading virology lab isolates the Sao Paulo Virus and publishes the genetic characteristics, starting the race to develop a vaccine. The first potential vaccine culture is produced and tests begin on volunteers.

C. Pandemic Response – Variant (a): Poor Management of Response

A variant of the scenario that could be considered is that the features of stage C, as described above, are made significantly worse by a series of factors. These include a long delay by WHO before declaring a global pandemic. The Pandemic Response Plans of governments are activated late and are poorly implemented, resulting in a failure to slow the spread of the disease and higher death tolls.

Hospital emergency capacities are already constrained through several years of austerity measures and low levels of investment, making it difficult to resource the spare beds and emergency wards needed. Facilities such as critical care facilities, ventilators, and specialist consultants are in short supply. Stockpiles of anti-virals and antibiotics are low.

Public health staff themselves suffer high levels of infection which disables the provision of front-line emergency healthcare.

Public transport systems, power production, essential services are all impacted by severe absenteeism which results in severe and prolonged power blackouts, delivery shortfalls, and shortages. Panic-buying by general public reaches extreme levels. Sold-out supermarkets, petrol stations, pharmacies, etc. are not able to be re-stocked. Infrastructure failures and overloads compound the chaos. Internet and phone systems are overloaded by people trying to work from home and service is severely degraded.

The public starts to panic in response to rising numbers of deaths and infection cases and failures in essential services. This is poorly handled and government communication appears slow and secretive. A number of poor decisions are made by the authorities that further enrages the general public, including the use of mass-graves for the dead, and the evacuation of government officials to rural retreats.

A breed of 'stay-home activists' promotes anti-government protest and a campaign to 'take control of our own health'. This movement claims that governments have delayed implementing pandemic response measures and have put economic productivity concerns ahead of public health priorities. Social media provides channels for self-organization of 'help-ourselves' groups. The campaign encourages people not to go to work, and to commandeer essential supplies. Shortages of essential supplies leads to raids on pharmacies, medical delivery trucks, and supermarkets. Protests, looting and riots are suppressed by armed police.

Vital medical supplies, such as Tamiflu and other anti-virals are in short supply. These exchange hands on the black market for high prices.

D. Vaccination Phase

The timing of the vaccination phase is a major variable in the development of the scenario. If it can occur fast enough, then the death toll can be significantly reduced, the spread of the epidemic reduced and the overall impact mitigated. In this scenario, the expected case is for vaccine to start to become available in quantity three months after the pandemic outbreak. This is several weeks faster than occurred in 2009. It occurs around the peak of the infection wave. (In the second variant of the pandemic scenario, it occurs much later).

There are continual announcements about the status of vaccine trials, the approval for use by the Federal Drug Administration and other drug regulators, the commencement of manufacturing processes, and the likely arrival dates of vaccine. These announcements boost public morale and give hope to the population. Tests show that the vaccine has limited side effects and an efficacy of 70% - (the percentage of those vaccinated who will not become infected if they are exposed to the virus).

Just as case loads are reaching very high levels, supplies of vaccine start to arrive in most countries. It is a race against time. As more of the population is vaccinated, the pandemic will slow up its progress.

Governments around the world have placed orders for the vaccine with the major pharmaceutical companies. One third of production is ear-marked for low-income countries. Vaccine production facilities have been expanded – there are now around 200 factories in 20 countries, most of which use a traditional chicken-egg incubation technique which takes several days to produce a dose, and collectively they produce around 100m doses a month.

Global production is maximised but demand is high across the world. Small amounts are given to each country and arrive at a slow rate, so vaccination is prioritised. Front-line healthcare workers are first, followed by the most vulnerable (pre-existing medical conditions, elderly, pregnant women) and then children. Vaccination centres are set up, and members of the public are allocated an appointment date for their vaccination. Nurses administer a single injection. Vaccine has to be kept refrigerated, even in transit. There are long queues of people at each vaccination centre but the processing of large numbers of people quickly is very efficient.

The mood of the general public becomes more positive as it becomes apparent that the vaccination programme is beating the pandemic – they can see that this is the beginning of the end.

D. Vaccination Phase – Variant (b) Difficult Vaccination Complications

A variant of the scenario that could be considered is that the features of stage D, as described above, are made significantly worse by a series of complications arising in the vaccination phase. These are factors that cause delays and additional logistical burdens that slow up the arrival of vaccine and reduce the efficiency and effectiveness of the vaccination programme.

These include the fact that the complexity and unusual genetics of the virus makes it difficult to isolate and create a vaccine culture. This causes a long delay before the first vaccine culture is available.

When clinical trials are finally carried out on a sample of volunteers, the trial results are problematic – the vaccine causes side-effects, particularly in certain sub-groups of the population. It requires re-design and retesting, which lengthens the time before the vaccine can be certified as safe by FDA.

The vaccine efficacy is found to be less than 60%, and unfortunately requires two injections 24 hours apart to build up the that level of immunity. Adjuvants are unable to boost the efficacy further.

The manufacturing of the vaccine is more complicated than normal: The virus is too virulent for traditional chicken-egg manufacturing process, as it kills the egg embryo. Vaccine production is a slow process, and although more factories are allocated to manufacture, they can only produce 30m doses per month – only a third of the rate that might have been expected.

The vaccination programme is more logistically complicated – each person requires two injections 24 hours apart. They have to queue up twice, making the process more complex and slower to administer. It takes much longer for a significant proportion of the population to get vaccinated. The pandemic continues to spread, finally starting to exhaust under its natural processes.

The mood of general public stays pessimistic as it takes a long time for the vaccination programme to slow the advance of the pandemic.

E. Post-peak tail-off

The wave of illness has peaked, as the number of new cases is diminishing week by week. The expectation is that the pandemic is conquered, but the peak marks roughly the half-way stage in the pandemic. The public starts to demand the relaxation of the restrictions that are in place. Some local authorities accede to these demands and allow schools to re-open and other public activities to resume. In almost all localities where this occurs, infection rates suddenly increase again within a few days, forcing authorities to reinstitute their controls.

There is only frustratingly slow progress towards returning to pre-pandemic life. It is evident that it will be a long slow process to kill off the pandemic. Companies re-orientate and prepare for resumption of normal business; however a continued incidence of new infections prevents normal activities. Absenteeism continues to inflict disruption across multiple economic sectors. The public is losing tolerance during the long wait for resumption of daily life.

Companies that are well prepared compete vigorously to take market share from still-struggling competitors. Individuals who have been vaccinated, and those who have had a dose of the San Paulo Flu and recovered, are 'the immune' – they are unlikely to become infected and can return to work. These individuals become valuable in the workplace as their risk of falling ill is less than colleagues who remain susceptible. Companies set up monitoring and registration schemes to identify those in their workforce who are immune. Some companies offer hiring bonuses and premium pay rates for immune staff. A number of companies seek advantage over their competitors through rapid recovery of their activities.

After the pandemic has subsided, there is a public clamour that such an event should never be allowed to occur again. Post-event reviews, government committees, and international investigations prompt a new regulatory framework for managing pandemic risk, both as a public healthcare issue, and as a business risk management problem to prevent recurrence of disruption. New regulations are put into place requiring businesses to conform to new procedures, adding costs for businesses to operate.

F. Possible Resurgent Waves

The Sao Paulo Flu virus displaces H1N1 as the endemic seasonal flu strain in common circulation. The following winter sees a very strong seasonal flu wave throughout the population as the new variant takes hold. In this wave, many elderly and young children catch the flu and are made unusually sick as a result. Death rates are unusually high in the elderly. This resurgent wave of the virus causes another period of disruption over the winter, with absenteeism resulting from employees having to look after old and young relatives affected by the new flu wave.

A particular strain of the new variant acquires Tamiflu resistance – people treated using Tamiflu no longer respond. This deprives medical science of a key weapon against the virus and increases the death toll of the winter wave. The circulation of a strain that is resistant to antivirals is a real concern to public health officials. They begin a major programme of drug development to find a new treatment for the new strain.

The resurgence of the pandemic has a major effect on public morale, with the realisation that the new influenza virus is going to be around for a long time, causing an elevated level of winter flu deaths in most countries each year.