

Use Cases and Competency Questions for the Management of Public Health Emergencies

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1 Introduction

In this report, we define thirteen public health emergencies use cases and corresponding competency questions. Each use case describes a specific persona of public health emergency and a specific task that persona performs that relies upon data to be properly performed. The use cases are drawn from government departments, medical institutions, medical staff, citizens, patients, etc. Competency questions helps to evaluate a public health emergencies related ontology's question answering and/or information retrieval capabilities. [1]

2 Use cases and competency questions

2.1 Disease Tracing - Epidemiology

The public health department needs to understand the development and evolution of an epidemic. Some tools and models can help predict future trends and understand various situations that may occur. In addition, the collection and analysis of epidemic data can help estimate the impact of epidemic prevention measures. For example, by comparing the daily infection numbers of the city before and after blocking policies were implemented, it is possible to judge whether the measures are effective. Predicting future trends of epidemics through forecasting tools can help public health departments adjust the duration of epidemic prevention measures. The government also tracks the epidemic in real time in order to formulate timely response measures, coordinate medical resources and equipment and prevent the spread of the epidemic.

Hospitals must test patients when they are admitted to hospitals. If the patient's symptoms are suspected to be an infectious disease, corresponding isolation and treatment measures are taken. The case should be reported to local health and epidemic prevention agencies according to the regulations. The health and epidemic prevention agencies should check for other recent local cases with similar symptoms and send samples for analysis of known or emerging infectious diseases. Once infectious diseases are diagnosed, if the symptoms are severe or the number of cases exceeds a threshold, they must report to the higher authorities. The patient information, such as address, occupation and itinerary should be collected to analyse their potential exposures, in order to determine the source of infection. Some information is summarized by city government and released to the public, such as the number of new confirmed cases, itinerary of cases and regional risk levels.

Competency questions:

- 1) For a patient y that tests positive, what is the patient's demographic information, and where and when were they tested?
- 2) For a patient y that tested positive, what was their movements for the last n hours?
- 3) For a patient y that tested positive, what were their symptoms and when did they appear?
- 4) What was the result of the laboratory analysis of the virus sample from this patient y ?
- 5) How many cumulative confirmed cases of the disease d are there in the area a at time t ?
- 6) How many cumulative deaths of the disease d are there in the area a during time period p ?
- 7) What are the current medium-risk districts in the city c ?
- 8) What is the reproduction number of disease d in the area a at time t ?
- 9) What is the current population of the area a , how many people are seniors, children, etc.?
- 10) Which day had the most confirmed new cases of the disease d during time period p in the area a ?
- 11) Does the reproduction number of disease d increase or decrease in the area a at time t compared to the previous day?

- 12) Who was the first confirmed case of the disease d in the area a and when reported the confirmed cases?
- 13) Which areas had 0 confirmed cases of the disease d before time t ?
- 14) Whether these patients with similar symptoms had visited the same place during time period p ?
- 15) How many and what percentage of the people within the age range $[x,y]$ have come down with the disease d during the time period p ?
- 16) What is the average number of daily infections in a time period p before and after the implementation of the policy z ?
- 17) Whether the average number of daily infections in a time period p bounced back after the cessation of the policy z ?
- 18) How many new hospitalizations, intubations, and ICU admissions due to the disease d are there in the area a at time t ?
- 19) How many Emergency Services calls (e.g. paramedic/ambulance) due to the disease d are there in area a at time t ?

2.2 Contact Tracing

A citizen took the train from Beijing back to his home in Jinan. He felt unwell after returning home. He is not sure if he has a common cold or COVID-19. He first used an APP on their phone to determine if there are new cases of COVID-19 in a district of Beijing he had been to, and then he searched the trains he took to determine whether there were any passengers with confirmed COVID-19 among his fellow travelers. The public health department must contact everyone the citizen came into contact over the last 7 days.

Competency questions:

- 1) Where has the citizen x been to during time period p ?
- 2) Has the citizen x taken the public vehicle recently? If so, what was the vehicle number, when and where did the citizen x get on and off the vehicle, and where did they sit in the vehicle?
- 3) Who were the other passengers on the vehicle that the citizen x took at time t ?
- 4) Are there confirmed cases in the location l that the citizen x has been to during time period p ?
- 5) Who were exposed to the citizen x in the location l during time period p ?

2.3 Testing

Person wishes to determine whether they have a disease. They search on a government online system that identifies where they can have the test performed, and schedules an appointment for them. Once the test is performed, the person can check online for the status of the test. The public health department can also review testing results, time and location. When a testing result of a patient is positive, the hospital reports it to public health department and immediately isolate the patient for further testing and treatment.

Covid-19 has revealed great disparities across groups defined by age, comorbidities, occupation and many other characteristics. Public health department needs to collect sociodemographic data and conduct further analysis to more fully understand the impacts of COVID-19 on vulnerable populations in order to inform actions to mitigate these effects and promote equitable health outcomes. It is important to protect vulnerable persons as much as possible. [2]

Competency questions:

- 1) Which hospitals provide testing for the disease d in the area a at time t ?

- 2) Where, when and what was the result of citizen x's last epidemic test for disease d?
- 3) If positive, what is the end date for self-isolation of citizen x?
- 4) Was the citizen x symptomatic at time of test for disease d?
- 5) If the citizen tested positive, what comorbidities do they have?
- 6) When can a citizen make an appointment for testing of disease d at hospital h?
- 7) How many citizens have made an appointment to perform a test of disease d at hospital h during time period p?
- 8) How many/percentage of people tested positive/negative for disease d in area a during time period p?
- 9) How many laboratory tests for the disease d are being done in area a at time t?
- 10) What is the percentage positivity rate for disease d of all laboratory tests in area a at time t?
- 11) What is the prevalence of Mutations of Interest or Variants of Concern?
- 12) What was the reason for obtaining test for disease d of citizen x?
- 13) Does the citizen x require referral to public health department for contact tracing?
- 14) What is the likelihood of error for citizen x's test result for disease d?
- 15) What areas experienced clusters/outbreaks during time period p?

2.4 Infection Prevention for Medical Personnel

The public health department must ensure the health of medical personnel. Medical personnel should report their symptoms each day and be tested regularly. Once medical personnel are infected, they should be isolated and treated immediately and their close contacts should be traced to avoid nosocomial infection.

The department also needs to coordinate medical personnel based on the severity of the epidemic and the number of patients, and decide whether to redeploy doctors and nurses from other regions to avoid medical personnel shortages.

Competency questions:

- 1) What are the symptoms of medical person x on day y?
- 2) What is the test result for medical person x on day y?
- 3) What is the planned and actual number for each category of medical personnel for day y?
- 4) Which medical personnel in the hospital h have/have not been fully vaccinated?
- 5) Which medical personnel in the hospital h are temporarily redeployed from other regions?
- 6) Who is the epidemic prevention worker for location l at time t?
- 7) Are there any medical personnel currently infected with disease d in the hospital h? If so, how many?

2.5 Vaccination Management

The public health department wishes to manage the roll out of vaccinations to the population. They have developed a risk-based system that takes into account, pre-existing conditions, age, living environment, etc. They wish to both notify who is eligible for a vaccine, and where and when to get it. Citizens obtain information related to vaccination through the system so as to obtain vaccination conditions, vaccination locations and charging rates, etc. Once someone receives a vaccine, they want to track their receiving of boosters, and remind people when the booster is available. Public health

department also needs to inform and promote vaccines to citizens and overcome barriers to vaccine acceptance based on vaccination rates. For example, SMS reminders of vaccination are sent to eligible people through the system.

A hospital provides testing and vaccination services of an epidemic disease, and they want to know the status of these people after the vaccination and whether they have had any adverse reactions. Using the information of the patient registered in the system, the hospital contacted them and collected information about their symptoms after receiving the vaccine.

The system will also support the querying of the data by various organizations to ascertain whether a person is fully vaccinated. For example, if a child is eligible to return to school, or a front-line healthcare worker can return to work.

Competency questions:

- 1) Who is eligible, and has not received, for the n^{th} dose of vaccine against the disease d in area a ?
- 2) Where has the citizen x been vaccinated against the disease d , and how many doses have they received?
- 3) What proportion of people in area a are in Highest Priority group, 2nd highest, 3rd highest, etc. for receiving the vaccine against the disease d ?
- 4) What is the proportion of people who have received notice of eligibility for vaccine against the disease d in their primary language in the area a ?
- 5) What is the proportion of people in area a who indicate that they have confidence in the vaccine against the disease d (confidence rate)?
- 6) What is the proportion of people in area a who indicate that they will consent to receiving a vaccination against disease d (acceptance rate)?
- 7) What is the proportion of people in area a who indicate that they want to book an appointment of the vaccine against the disease d ?
- 8) What actions are being taken to listen to social media and counter vaccine against the disease d misinformation in area a ?
- 9) How many (and/or percentage) people in area a have received the n^{th} dose of vaccine for disease d at time t ?
- 10) How many (and/or percentage) of people in age range r have received the n^{th} does of vaccine for disease d at time t ?
- 11) Which hospitals provide vaccination for the disease d in area a at time t ?

2.6 Vaccine Efficacy Management

Due to the speed with which vaccines are being developed, the length of time of stage 3 testing and size of the test group, test results may not provide sufficient information as to the efficacy of a vaccine. Public Health would like to track each person who has received a vaccine and if they have experienced Adverse Events Following Immunization (AEFIs). In particular, they would like to track whether they have become ill and if so what are the symptoms, if they have visited as hospital, if they have been admitted to a hospital, have been in intensive care and have died. This information will be used to better understand who should receive the vaccine, the period during which its efficacy increases/decreases, mortality rates, side effects, etc.

Competency Questions:

- 1) When and what vaccine did the citizen x received?
- 2) What is the contact information of a vaccinated citizen x for disease d ?

- 3) What category of AEFI (including Local, Systemic, Allergic, Neurological, Other) did the vaccinated citizen x experience and when?
- 4) How long after the citizen x receive his/her n^{th} dose did he/she experience an AEFI?
- 5) Does the citizen x meet the case definition for an AEFI (i.e. temporal relationship with vaccine and not due to other known cause)?
- 6) Did the citizen x with an AEFI have any relevant medical history (concomitant medications, known allergies, acute illness)?
- 7) Has the citizen x had an AEFI with previous immunization?
- 8) Has a report of citizen x been submitted to the AEFI committee/governing body?
- 9) Did the citizen x test positive for the epidemic disease d following at least one vaccine dose (partial or full vaccination)?
- 10) Did the citizen x test positive for the epidemic disease d prior to onset of immunity (within 14 days of first dose)?
- 11) Did the citizen x test positive for the epidemic disease d following full immunization (actual breakthrough case)?
- 12) Did the citizen x seek medical attention, and if so where and for what?
- 13) Was the citizen x admitted to the hospital, if so why?
- 14) Was the citizen x admitted to intensive care, and if so how long were they there?
- 15) Did the citizen x die, and if so how long after receiving their first or second dose?

2.7 Vaccine Distribution Management

The city/state/province/country receives vaccines from multiple sources both within the country and outside of it. The distribution team has to know when and where and what type of vaccine they are receiving. They have to be able to distribute it across the country. They have to manage distribution centres at both the regional and local levels. They have to know the status of all vaccines through the supply and distribution chain. They have to balance supply and demand. They have to move quickly in response to changes in supply and demand.

Competency questions:

- 1) What are the planned shipments of vaccine x that are to be received from manufacturer m during time period t?
- 2) What is the inventory of vaccine x at location y?
- 3) What is the status of vaccine x at location y?
- 4) What is the planned allocation of vaccine x for location y during time period t?
- 5) How many vials/doses of vaccine x were delivered to location y during time period t?
- 6) How many doses of vaccine x were administered at location y during time period t?
- 7) How many citizens have made an appointment today to be vaccinated at location y?

2.8 Transportation Management During Epidemic

The government may need to manage public transportation, travel and emergency supplies transportation to prevent the spread of an epidemic. For example, for some high-risk areas, local road and waterway transport, urban public transport, railway transport and civil aviation transport services need to be suspended. The government departments also need to allocate vehicles to ensure the

commuting of medical personnel, police officers, epidemic prevention workers and those involved in the operation of basic city services, as well as the transportation of epidemic related resources. For areas with low risk, the government may wish to set up sites to check and register people entering the area on public transport or private vehicles to avoid importing cases. Governments should also release information on local traffic control measures and suspension of passenger services in a timely manner.

Competency questions:

- 1) What public transportation is suspended during time period p?
- 2) How many people arriving in the city c at time t are from medium-risk areas?
- 3) Which streets or roads are closed at time t in the area a?
- 4) How many private vehicles entering the city c was checked at site s during time period p?
- 5) How many people entering the city c in total during time period p?
- 6) Can a citizen x in location l1 still get to location l2 at time t?
- 7) What is the epidemic risk level of location l?
- 8) What vehicles are allocated to moving medical personnel, essential workers, resources, etc.?
- 9) When will a suspended public vehicle v resume service?

2.9 Mental Health Management

An epidemic has an impact not only on people's physical health, but also on their mental health. There has been a significant increase in the number of people suffering from mental stress as a result of an epidemic. People fear being out in public, they are concerned with the health of family and friends, they fear losing their jobs, they fear losing their homes, they fear what the future will bring. These worries and fears are normal psychological events. In addition, there is particular concern with the mental stability of essential services providers. Public health department should pay attention to mental health of its citizens and essential service providers, and plan for and deliver support where possible.

Competency questions:

- 1) What proportion of people in area a report their current mental health state as "Very good" or "Excellent"?
- 2) What proportion of people in area a report that they are concerned about their mental health?
- 3) What proportion of people in area a report increased feelings of loneliness or isolation?
- 4) What proportion of people in area a report increased feelings of depression and/or anxiety?
- 5) What proportion of people in area a report that they are concerned about their personal finances?
- 6) What is the median wait time for psychiatric care in area a at time t?
- 7) What is the median wait time for psychological care and/or psychotherapy in area a at time t?
- 8) What proportion of people in area a report difficulty accessing mental health supports?
- 9) What proportion of people in area a report an increase in substance use (alcohol, tobacco, narcotics, etc.)?
- 10) What proportion of people in area a report that they have had thoughts of suicide or self-harm?
- 11) How many people have visited an emergency department reporting of stress, or mental health crisis in area a at time t?
- 12) How many people have been hospitalized due to mental health crisis in area x at time t?

- 13) Has there been an increase in the level of domestic violence in area a at time t reported by the police?
- 14) How there been an increase in the number of prescriptions for anti-depressants or anti-anxiety medication in area a during time period p?
- 15) What percentage of families have lost family members because of the epidemic in area a during time period t?
- 16) Has there been any increase in the number of people receiving mental counselling at area a at time t?
- 17) What is the rate of unemployment in area a at time t?
- 18) What proportion of healthcare workers report an increase in job-related stress in area a?
- 19) What proportion of healthcare workers report new onset of PTSD or PTSD-like symptoms in area a?
- 20) Has there been an increase in the rate of sick-time or short-term disability taken by healthcare workers due to job-related stress in area a?

2.10 Food Poisoning Management

One type of public health emergency is food poisoning. Public health departments shall monitor, analyze, predict and provide early warning of possible food poisoning incidents in cities and their risk factors.

Once there is a food poisoning incident, the affected citizens should immediately contact a nearby hospital and report the location, time, the number of people poisoned, main clinical manifestations and poisonous food to the health department, so that the health department can investigate the cause and provide treatment. Public health departments shall classify food poisoning incidents and implement corresponding measures according to the severity and the number of people affected. The health department collects information on the occurrence, development and treatment of food poisoning incidents, monitors dynamic progress and performs real-time analysis to provide a basis for leaders to make decisions. The health department also organizes experts to formulate emergency strategies and preventive control measures for food poisoning events, and carries out impact evaluation. If it is suspected to be a wilful, man-made poisoning event, the public security department should be contacted in time to assist in the investigation.

Competency questions:

- 1) Where and when did the poisoning event e take place?
- 2) In the case of food poisoning at time t and location l, how many people were poisoned?
- 3) What is the poisoning symptom of the patient y?
- 4) In the case of food poisoning at time t and location l, how many people showed mild symptoms of poisoning?
- 5) In the case of food poisoning at time t and location l, how many people showed severe symptoms of poisoning?
- 6) In the case of food poisoning at time t and location l, what food did person y eat?
- 7) In the case of food poisoning at time t and location l, which hospital were the poisoned people sent to?
- 8) In the case of food poisoning at time t and location l, is the poisoning event suspected to be human made?
- 9) Where did person y eat the food? Home? Restaurant? Street vendor?
- 10) If person y ate the food at home, where did they purchase it?

2.11 Drinking Water Pollution Management

Contaminated drinking water is another type of public health emergency. It can be caused by polluting the source of the water, failures in its processing, or problems in its distribution. If the drinking water is contaminated, the public health department needs to first treat the affected citizens, and then cooperate with environmental protection department and water conservancy/distribution department to investigate major pollution sources and major pollutants. The analysis includes location and status of local water sources, the discharge of wastes by nearby enterprises, the use of pesticide fertilizers nearby and discharge of local sewage. It is necessary to check the environmental sanitation of the water supply company, the health status of the staff, whether the water supply pipe network is broken, etc. Depending on the investigation, the local government determines whether to suspend the water supply.

Once drinking water pollutants have been eliminated, the relevant hazardous factors have been effectively controlled, the water quality test results have met the national sanitary standards for drinking water and there are no further cases occur, then the water supply can be resumed.

Competency questions:

- 1) Where and when did the drinking water contamination event take place?
- 2) In the case of water contamination at time t and location l , how many people were affected?
- 3) In the case of water contamination at time t and location l , how many people were taken to the hospital?
- 4) What is the common symptom of the affected citizen at time t and location l ?
- 5) Which hospital were the affected person y sent to?
- 6) What company is responsible for the drinking water supply for the location l ?
- 7) Are there health problems for employees at the drinking water supply company c ?
- 8) Where is the source of the drinking water at location l ?
- 9) Is there a biological, chemical or physical cause of the contamination of drinking water in the location l at time t ?

2.12 Emergency Medical Resource Management

In an emergency, the public health department needs to allocate medical equipment and supplies. For example, the production, inventory, and distribution of PPE is critical for a respiratory disease pandemic. Severely affected cities may receive medical resources and supplies donated by other cities or even countries. Organizations need to inventory medical equipment and supplies, and distribute them as directed to meet the needs of front-line medical personnel. For example, the public health department tracks inventory of N95 masks, surgical masks, PPE, eye wares, gloves, and sanitizer in terms of "estimated number of days of PPE available" for hospitals and paramedic services. Different types of resources are suitable for different groups of people. For example, some types of masks are not suitable for use by medical personnel, but can be used for preventive purposes by citizens. Another task is to monitor bed usage and decide whether to allocate mobile hospitals and/or build new mobile, temporary or permanent hospitals.

Competency questions:

- 1) What is the available hospital capacity in area a at time t of acute care beds, ICU beds, Ventilators, etc.?
 - a) How many hospital beds does the hospital h have at time t ?
 - b) How many hospital beds are occupied in the hospital h at time t ?

- c) How many hospital beds are available in the hospital h at time t?
- 2) What types and number of medical resources does the hospital h lack at time t?
- 3) What is the inventory of resource x at distribution centre y?
- 4) When will the next shipment of resource x arrive at location l?
- 5) What type of masks is suitable for medical personnel?
- 6) How many medical resources of type e (e.g., personal protective equipment) have been delivered to the hospital h during time period p?
- 7) How many medical resources of type e (e.g., disposable surgical masks) are consumed on average in a day during time period p at location l?
- 8) How many patients can the mobile cabin hospital h serve at time t?

2.13 Stakeholder Collaboration/Volunteer Management

Although the public health department takes the lead in public health emergencies management, many epidemic prevention measures and activities require coordination between many departments. For example, the transportation department may impose traffic control on areas severely affected by the epidemic. However, the transportation of medical supplies and the commuting of medical personnel need the coordination between public health departments and transportation departments to open up special routes. Public health needs to ensure that the various departments/organizations have clear and mutually agreed upon roles and responsibilities. Public health also needs to be coordinated with external stakeholders, where necessary.

There may be a shortage of staff because of the outbreak of epidemic. Local volunteers need to be recruited, trained and allocated where needed in the health system.

Competency questions:

- 1) What goals have and have not been satisfied?
- 2) What are the tasks that need to be performed to meet goal g?
- 3) What impediments exist to achieving goal g (e.g., increasing ICU beds)?
- 4) What roles in hospital h are unfulfilled?
- 5) What skills are necessary to fulfill those roles r?
- 6) What government departments that collaborate with to fulfil those roles?
- 7) Are there substitutable skills that can fulfill the roles r?
- 8) What roles can be filled by unskilled volunteers?
- 9) What type of training is required for the volunteers?
- 10) How many volunteers have mastered the skill that role r needs in area a at time t?

3 References

[1] Grüniger, M., and Fox, M.S., (1995), "Methodology for the Design and Evaluation of Ontologies", Proceedings of the Workshop on Basic Ontological Issues in Knowledge Sharing, IJCAI-95, Montreal.

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