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Application of Disaster Management Information for the COVID-19 Pandemic

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Abstract. Since end of 2019, because of the worldwide spread of COVID-19, the whole world has been struggling for solutions to mitigate adverse impacts and worsening situations, which demonstrate very dynamic characteristics requiring high integration among government agencies to make decisions and deliver operation. Within countries around the world, most of disaster management agencies are the primary institutions working with health agencies to cope with health emergencies. To comparing disaster management with public health management, there are lots of common grounds like procedures to deal with emergency and allocations of resources. However, the differences between the two fields offer an opportunity for mutual leaning on best practices of emergency management. For example, in case of disaster event, for better response and control, commanding officials usually dispatch several teams and concentrate resources as much as possible to effectively respond to emergency. According to reports on containing COVID-19 spread, whenever any decisions should consider social distancing first that limits operational space because of safety reason. This paper explores possible collaboration between disaster management with public health management and discusses direction about how to apply information of disaster risk management for public health events. More focal topics concentrate on data processing of population distribution and information integration.

Keywords: COVID-19, Disaster management, Public health management, Information intelligence

1 Examples of Collaborations Between Disaster Management and Public Health

COVID-19 has infected 100 million people and caused 3 million deaths [1] that not just bring global health crisis, but also all kinds of interruptions to operations of governments and business, livelihood, education, and other activities. Before massive vaccination could deliver herd immunity, “Social distancing” and “Quarantine” are two basic approaches to contain the spread for buying more time to develop effective “antidote” to solve this global crisis. Looking history of public health emergencies, Spanish flu in 1918, SARS in 2003 and H1N1 in 2009 have given lessons to the world in handling global pandemics through assistance science and technology. From Spanish flu to

COVID-19, besides medical research to find out treatments and vaccines, how to effectively conduct “Social distancing” and “Quarantine” that demands monitoring developing situations, comprehensive information integration, risk communication, emergency operation, information facilitation and other measures which help decision making. All possible measures mentioned above are the same ones for disaster management covering phases of mitigation, preparedness, response and recover.

Since human beings are the primary target to protect by risk reduction of natural hazards or pandemics, common grounds of identifying social and physical vulnerabilities are to build up cross-cutting collaborations in sharing of information, technology operation principles, resources, and experiences. For example, seismic disaster reduction, disaster managers need patterns of population distribution which help to highlight disaster hotspots in case of large-scale earthquake and provide a risk profile to decision maker to deliver a drill or respond to emergency. Likewise for containing spread of pandemic, density and distribution pattern of population are also key indicators to pinpoint high-risk communities and propose strategy to build “firewall” for isolating infections. Therefore “Human-centric” countermeasures can establish good connections for inviting more synergies from disaster managers and public officers.

Traditionally, disaster managers apply census for exploring social and physical vulnerabilities. Among all categories of census data, population is the one of the most applicable information to estimate exposure and risk of both urban and rural areas. After collecting original population data and expanding the information on a GIS platform, it offers a map of population distribution. To increase the resolution of population distribution map, it requires additional processes to make the map more informative for application in disaster risk management. A case done by the National Science and Technology Center for Disaster Reduction (NCDR) is a good practice of data processing on population distribution.

Having collaboration with government, NCDR integrates census and tax information to make maps for seismic risk identification. The population data of census can tell numbers, ages, genders, and address of demographic structure. Tax information of residential housing can tell floor areas to accommodate residents. Making estimates of population distribution by deriving equations between numbers of population and floor areas that leads to the first version of population distribution map of Taiwan. The map assists in understanding seismic profile for making plans of risk reduction and emergency preparedness. The Fig. 1 is the product delivered by NCDR based on 2010 Census [2]. For delivering the population density map (PDM) with better geo-spatial resolutions, a mesh with grid size of 500m by 500m is applied to divide the whole Taiwan into 13,2712 grids.

By overlapping the map with ground motion, casualty estimate, building damage estimate, soil liquefaction, etc. (See Fig. 2), the integrated map will give a comprehensive risk distribution for both planning phase and emergency operation. In case of an earthquake, the NCDR system would use real shake maps to estimate impacts, possible casualty, damage and interruptions to lifeline system and critical infrastructure. For study on Dengue, the map has been applied for tracing the spread and highlighting prioritized areas to disinfect. The PDM overlaps with investigations of *Aedes aegypti* that can identify hotspots requiring disinfection.

After typhoons or floods, some water-born diseases like pathogenic Leptospire and melinidosis are the two major concerns of public health, especially in flooded areas. To send warning to the possibly affected areas, the Center of Disease Control (CDC), Taiwan, in collaboration with NCDR, would use the PDM, floods map and rain forecast to give public health guidance to follow.

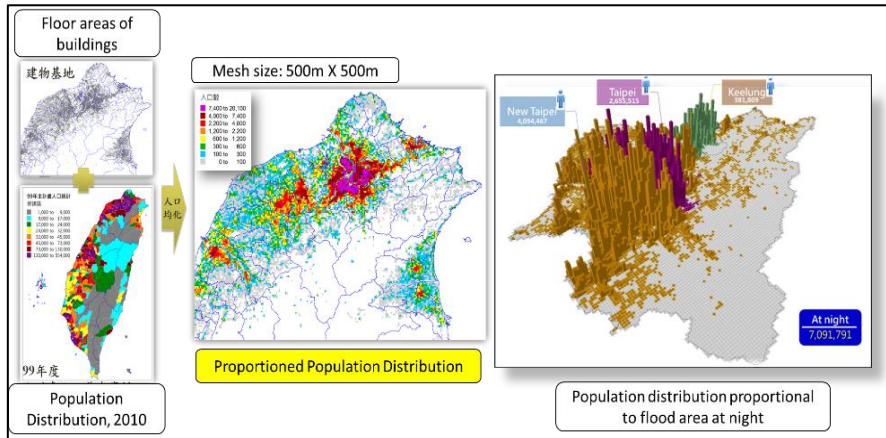


Fig. 1. Population density map based on grid approach by using 2010 Census.

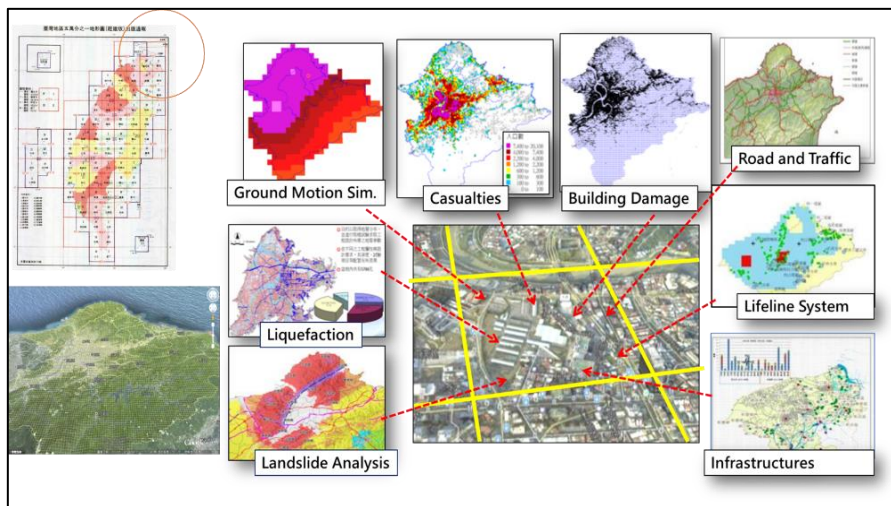


Fig. 2. Population distribution map integrates with relevant vulnerabilities and risks.

2 Unique Demands for Containing COVID-19 Spared by Applying Data and Information Prepared for Disaster Management

Examining the characteristics and assumptions of the PDM mentioned in section 1, the PDM can only static distribution of population based dwelling facts and assume the distribution is proportional to floor area. Therefore, the PDM is ideal for risk analysis of static, not dynamic, situation. In case of typhoon event, most people will stay at homes that meets the assumptions of the PDM and emergency responders can easily allocate personal and resources to high-risk districts after impacts assessment.

In fact, the living world is very dynamic according to different social activities around the clock or specific events like holidays. For seismic risk reduction, it has been a while to try to catch dynamic population density map (DPDM) for unpredictability of earthquake. To know how many and where people highly concentrate is always an urgent demand of emergency responding officers after a large-scale earthquake strike. Even with the-state-of-the-art technology in studying earthquake precursor, there are still few steps away to make precise prediction of earthquake. In recent years, user data owned by mobile service providers have shown a possible solution to depict dynamic characteristic of population by conducting near real-time analysis of mobile phone user, [3] – [10]. Most smart phones sold at mark are equipped with sensors measuring physical parameters including geo-location, altitude, motion status and vibration which can be regarded as a personal digital tag to tell the current environment that phone user is in. If mobile service providers can share the users' information without intruding personal privacy, it does make a huge leap in understanding dynamics of population movement. A mobile phone user survey reveals that 65% of office staff keep phones always-on [11].

NCDR has been collaborating with the Chunghwa Telecom (CHT) over 10 years in using phone user data to conduct time-dependent analysis of population. CHT has over 40% market share and its broadest service covers most corners of Taiwan. From 2019, CHT provides more precise data, which can give an update at 10-minute interval with 500m-by-500m geo-resolution. The new data offer a solid base to NCDR for producing DPDM (Fig. 3) and conducting more possible applications. DPDM can offer a window to look at 7/24 population movement, patterns of distribution and differences among areas. By adopting DPDM, NCDR helps to make plans for both central and local governments and provide scenarios for national earthquake drill. With DPDM, planners, decision makers or emergency responders can have a detailed picture of impacts. For example, when an earthquake strikes, NCDR's system can make impact assessment based on 10-minute-ago population distribution that gives primary suggestions for casualty check.

After outbreak of COVID-19, for enforcing measures of Social distancing" and "Quarantine", it needs scientific evidence to monitor movement and gathering of population to deploy necessary management and control. The requirements in understanding population for containing COVID-19 are similar to seismic risk reduction that demands dynamic characteristics of population movement. NCDR immediately convened

a taskforce for working out solutions aimed at pandemic control. During developing maps for COVID-19 monitoring, it requires indicators to define levels of mass crowd gathering for signaling warnings. As specified the collaboration between NCDR and CHT has been 10 years, it builds a good database for a long-term observation which can provide a baseline for comparisons of population density.

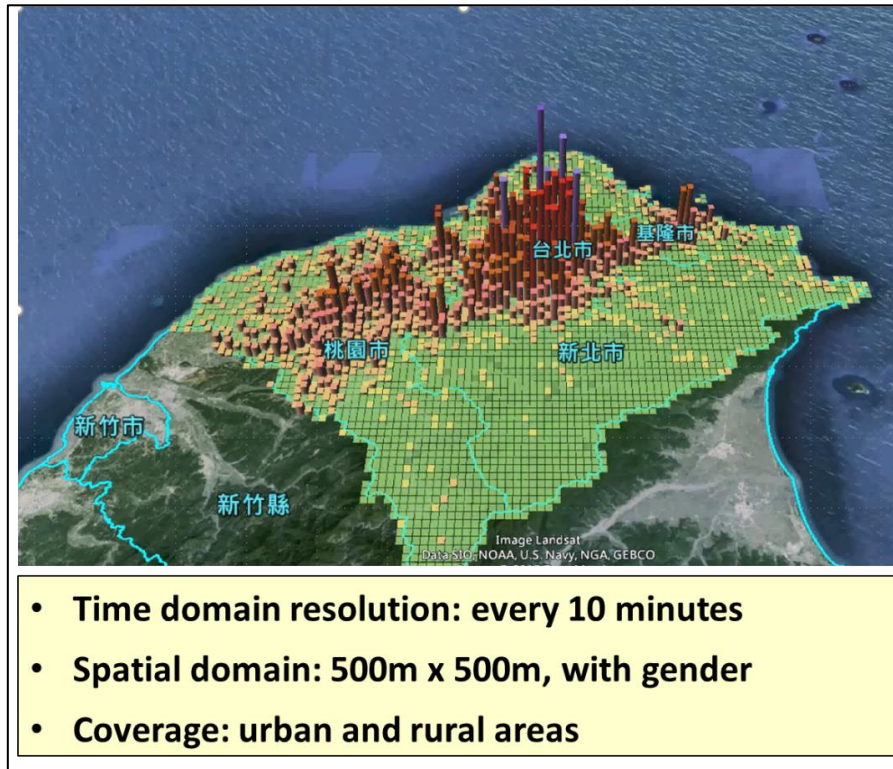


Fig. 3. The dynamic population density map (DPDM) of Taipei Metropolitan area produced by NCDR.

3 Applying the Dynamic Population Density Map (DPDM) for Mass Crowd Control During Holiday Under COVI-19

As requests by disaster managers and emergency responder, in case of sudden-onset events like earthquake or social disturbance, where densely populated areas are to identify hotspots to make plan for, check out or respond to.

Under guidance of COVID-19, lots of social activities are either cancelled or downscaled to satisfy demands for keeping social distancing since beginning of 2020 Chinese New Year Festival. When the 4-day spring break came in the early April 2020, lots of Taiwanese residents took this opportunity for having domestic tours, visiting

families or tomb sweeping. From news footages of over-crowded tourist spots, the Central Epidemic Command Center (CECC) launched messages through the Public Warning System (PWS) to warn citizens in these over-crowded areas and suggest on-the-way drivers avoid visiting the over-populated areas. Fig. 4 showed the population changes during April 1st ~ 5th. To illustrate levels of mass crowd the NCDR taskforce choose 3-week averaged time-dependent data as the baseline, the grey line in Fig. 4, for qualitative analysis.

To answer requests proposed by CECC to evaluate mass crowd movement, NCDR taskforce decided applying DPDM to provide geo-spatial and time-dependent factors for monitoring population movement. The following items are key elements to create an effective platform of monitoring:

1. Where and how to identify crowd movements through adopting management tools
 - The system should display and estimate locations and numbers of crowds.
 - Indicators identify the density of crowds could exceed allowable capacity or not.
 - Time-dependent increments helps to forecast the increasing or decreasing trends.
 - Channels inform citizens of taking actions.
2. Quick solutions by applying near-real-time dynamic population data
 - Non-privacy information produced by mobile service provider is to monitor the movements.
 - The analysis should be based on sufficient resolutions of time, every 10 minutes, and space, 500mX 500m grids.

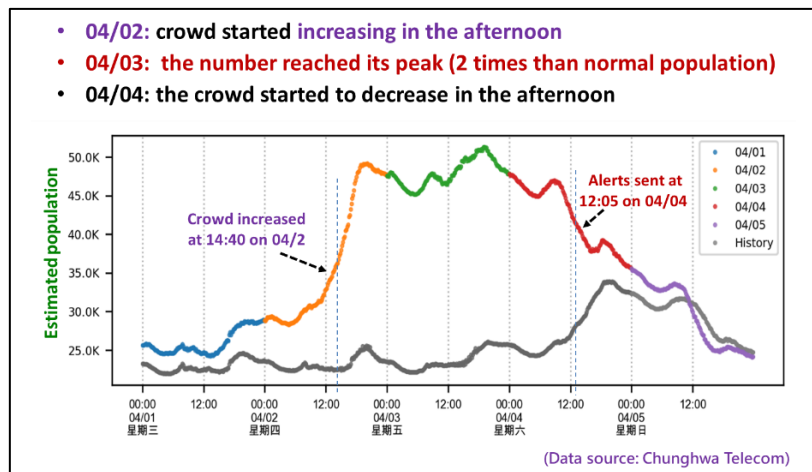


Fig. 4. The population movement during spring break in Hengchun Township.

4 Conclusions

To better engage disaster managers and public officers for better information share to cope with future and compound disasters, the following suggestions are proposed:

1. The cross-cutting usage of information should be the trend under all-hazards approach that can meet compound disasters like earthquake or flood response under influence of COVID-19. Data and information should provide multiple functions for diverse emergencies.
2. Disaster managers or researchers should extend collaboration with other community that can introduce innovation and build integration. Therefore, a mechanism or platform should be designed to routinely engage key stakeholders.
3. At information age, how information can be well transferred and understood by the public is an essential measure for emergency management, no matter disaster or epidemic. From current practices and observations, a clear and direct risk communication always requires scientific-based tools to produce correct information intelligence. And the last mile is to deploy effective and efficient channels to reach end users. The target end users could be citizen, disaster managers, emergency responders or decision makers. According to the actions taken by individual end users, information intelligence should be designed to offer clear guidance such like timing or procedures.

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