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WP-COVID, a Web Based Computer and Mobile Application for COVID-19 Disease Surveillance

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Abstract

Sri Lanka is at its 3rd phase of COVID-19 pandemic. Sri Lanka has a very efficient public health system. Though very comprehensive, the present disease surveillance system lacked real time epidemiological information. The computer and mobile applications were developed to provide illustrative, epidemiological information for real-time disease surveillance as opposed to the existing paper-based system, to be relevant in a world interconnected via the internet and geographical information systems. The new system well supplemented the existing disease system while providing detailed information for prompt COVID-19 control and prevention.

Key words: *COVID-19, WP-COVID, Disease Surveillance*

1. Introduction

Sri Lanka has been experiencing COVID -19 pandemic since 11 March 2020. The progress infection was very dynamic. A little was known then about the characteristics of the viral strain or the infection. Therefore, catastrophic experiences gathered from other nations demanded a multitude of health and non-health sector interventions to stop its spread. Sri Lanka was hugely successful in containing the first wave of the pandemic; the main strategy of control has been reducing the transmission through early diagnosis (by laboratory confirmation), contact tracing and isolating infectious and suspected patients (1).

Epidemiology is defined as the 'study of the distribution and determinants of health related states or events in human populations and the application of this study to the prevention and the control of health problems'(2)The fundamentals of epidemiology emphasizes on correctly identifying spatial information of the cases. The existing routine disease surveillance system of Sri Lanka identifies patients through the first contact care provider(3). It is praised as very comprehensive system by experts in Sri Lanka as well as in most modern countries. Though it is excellent as a routine surveillance system, it lacks facilities to process real time information. It was observed that, the existing system could be improved with the help of information technology and geographical information system to immediately identify patients and contacts for disease surveillance teams to act promptly(4). During the early days of the first COVID-19 wave, through a quick analysis of cases' addresses, the epidemiologists realized that they need a method to immediately identify epidemiological information of cases and contacts to decide on coordinating logistics, identifying geographical clusters of high risk, imposing lockdowns etc. Also, research have yielded results in favor of using more electronic and mobile devices to ensure epidemiological data accuracy (5).

Globally, there is a developing trend in adopting mobile applications for disease surveillance (6,7). Sri Lanka has a mobile penetration of a staggering 126% (8). The smartphone and use of electronic hand-held communicating devices use too has risen in parallel with the mobile phone usage(9). New mobile technology has become less expensive hence within the reach of most people (10). This background provides a platform for the disease surveillance process to function in a fully digitalized environment. Many industries such as postal, courier, construction, public transportation depend on global positioning systems for their logistics, supply chain management, marketing predictions and: monitoring and evaluation(10). Global positioning systems, that have been very useful in describing spatial information, which were once an expensive technology to which only the corporate clients had access to, have now become almost freely installed in handheld mobile devices. Thus, the easy availability of mobile devices leads the authors of this project develop a novel technological addition to the existing disease surveillance system of the country. The Provincial directorate of the western province had to play a key role in disease surveillance with the Ministry of Health, Sri Lanka Army, Sri Lanka Police and other stakeholders. The idea of creating an electronic platform was initiated from the Sri Lanka Army and the epidemiologists of the Provincial Directorate of Health Services of the Western Province.

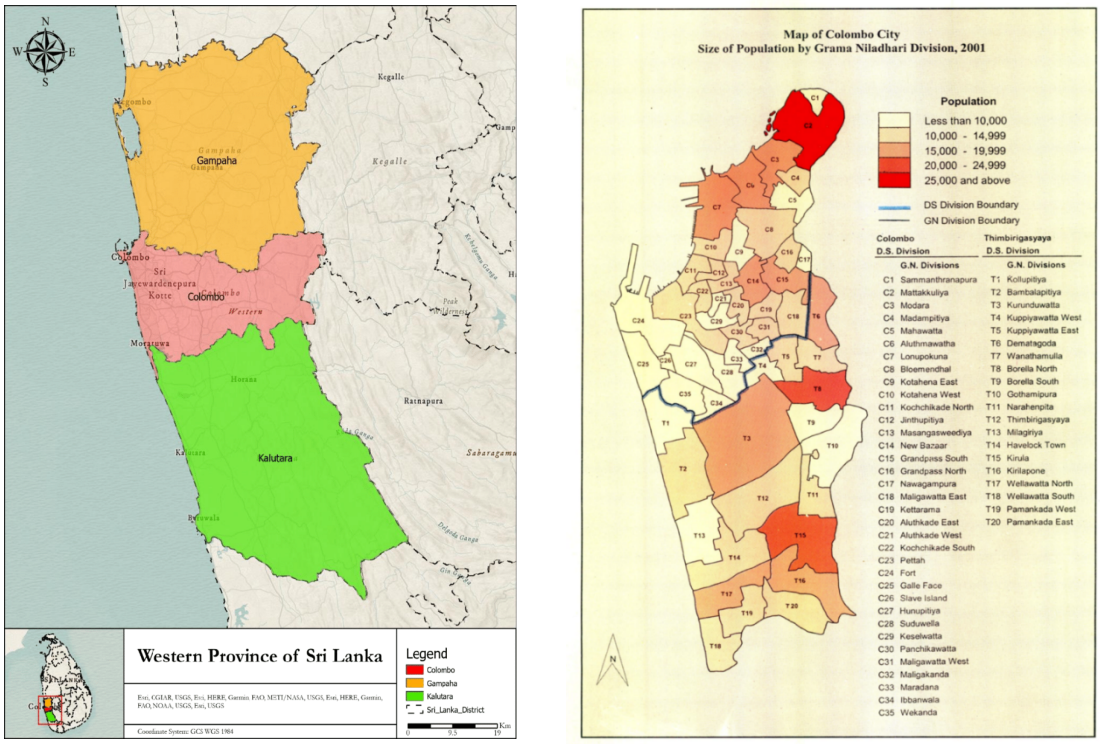


Figure 1: Map of the Western Province of Sri Lanka showing the three districts

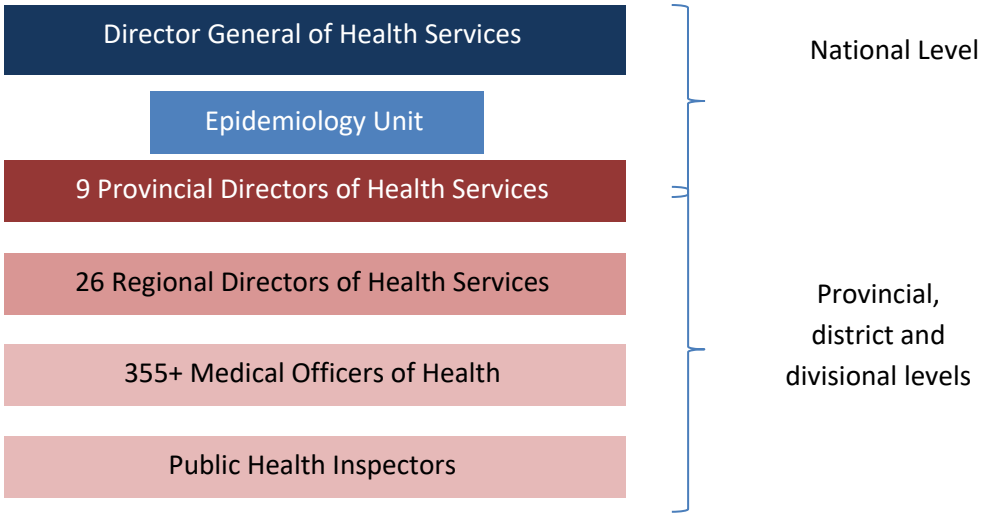


Figure 2: Governance structure of disease surveillance system

As shown in Figure 2, under the authority of the Director General of Health Services, the epidemiology unit acts as the National Center of disease surveillance. All provincial, district and divisional levels directly and hierarchically report to the epidemiology unit. The disease surveillance system in Sri Lanka is monitored by the epidemiology unit at the national level. The Disease surveillance system of the Sri Lanka usually starts at the time of suspicion of the disease. All medical practitioners are bound by the law to notify a noticeable disease on suspicion.

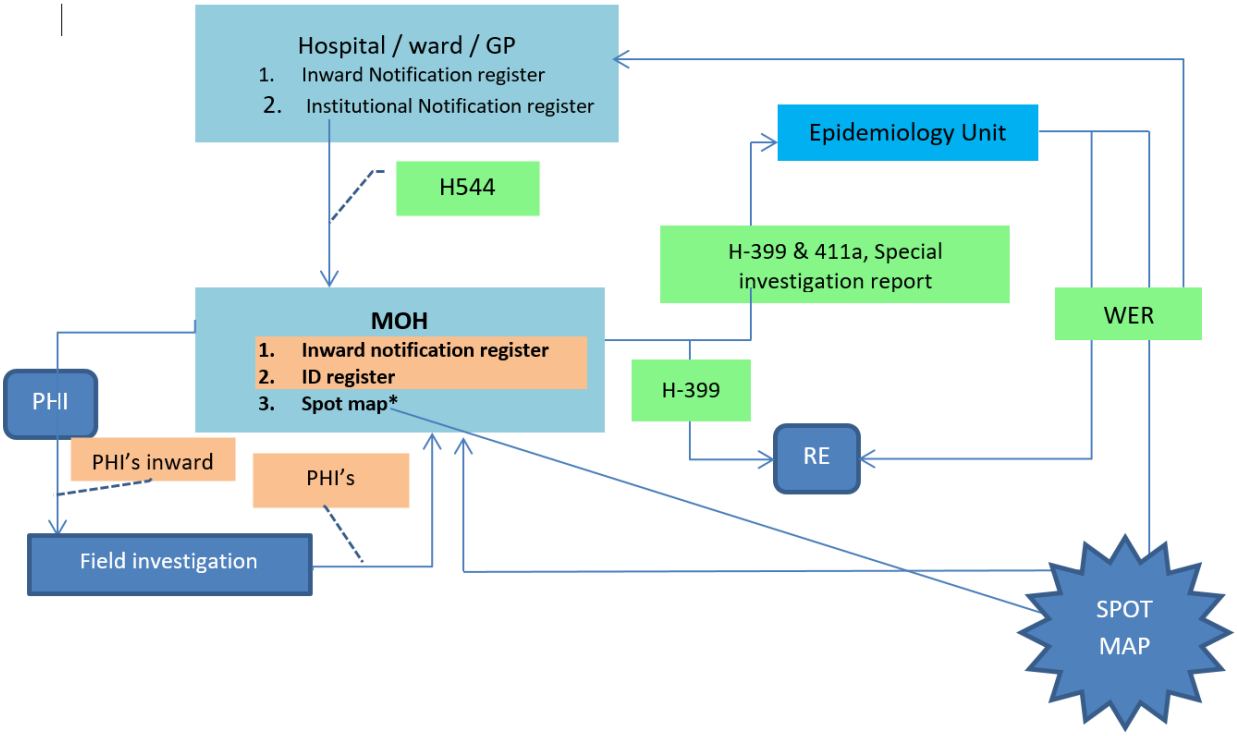


Figure 3: illustrates the disease notification system in Sri Lanka. Though it has much strength, there have been few weaknesses such as not being real-time and not having a laboratory surveillance system.

Spot map

Sports maps are like the crown jewels of epidemiology. John Snow, who is credited as the father of epidemiology made use of the first epidemiological spot map to identify the source of Cholera epidemic in London. These maps provide epidemiological data in illustrative manner in person, place and time. This instrument, though in a paper-based system had not been very effective, could be developed provide real-time information if proper data is provided to the map on timely manner.

Weakness of the existing system

The existing surveillance system of Sri Lanka provides the basis for control and prevention of any disease. Further, it has experts in epidemiology placed at the national, provincial and district levels. The 355 Medical

Officers of Health form a strong network which covers the entire island. The systems have its own weakness such as being passive, absence of laboratory integration, not being geared to collect information from the private and indigenous sectors.

2. Objectives

To develop a web based real time disease surveillance system for COVID-19 disease control and prevention

2.1 Specific objectives

1. Communicable diseases reporting system based on Web and Mobile Communication Technology to convey surveillance information and early warnings on outbreaks.
2. Review the spatiotemporal characteristics of COVID 19 and Dengue epidemic from global, regional and local perspectives.

3. Identify the impacts of natural and manmade factors on spatiotemporal distribution of COVID 19/ Dengue epidemic in Sri Lanka.

4. Develop a Geo-referenced GIS database on COVID 19/ Dengue epidemic in Sri Lanka.

5. COVID 19/ Dengue cluster base tracking system incorporate statistical analysis, spatial analysis, high risk areas, and density with analytical dashboard

6. Get information on the number of cases of COVID 19, Dengue and other important cases within given geographical area

7. Option for the user to get information from where testing service and treatment services can be obtained for COVID 19 and Dengue Fever.

3. Methods

3.1 Packages developed

Western Province COVID (WP Covid) WebGIS Application

Western Province COVID (WP Covid) WebGIS Application was developed in a combination GIS and web designing software and the server located in Sri Lanka Telecom. The application provides a geographical map with different layers for administrative areas, epidemiological data, security information, geographical information etc. Visual illustration of real-time data is the essence of this map.
Access: Only a selected group of individuals authorized by the heads of departments of who will be authorized to handle patient related information will have the access to this application. They will be responsible for the overall management of the package and data security.

3.1.1 Features of WP-COVID

Administrative areas layer: Sri Lanka is divided into 9 provinces, 26 districts, 332 Divisional Secretariat Divisions, 350 Medical Officer of Health (MOH) areas and 14,022 Grama Niladhari (GN) divisions and 67 functional police divisions. GN division is the smallest administrative division. An MOH areas is geographically

almost similar to a DS division with few exceptions. The web application's map was fed with layers for each of above administrative divisions. Epidemiological information could be filtered out to display the disease burden of each of those administrative divisions. Each area can be outlined, highlighted according to the developer's data display requirement in a user defined color.

Epidemiological data layer: Cases are displayed as a dot on the map. The color can be adjusted to display in any color. Each dot is marked based on the location address provided the PHI or MOH of the area. Web Geographical Information Systems can mark geographical location to the nearest 100m accuracy.

Case deletion: This is a smart feature which removes patient information (i.e., location address, age, sex) 14 days after diagnosing the case. A case, after 14 days of diagnosis will be considered cured, therefore removed from active cases.

Satellite Map: The map has been linked to Google Maps which provides satellite images to provide most accurate aerial views of geographical locations for easy identification of areas.

Risk categorization by area: Although the smallest administrative division is a GND, the package adopts a DSD as a primary area of focus for ease of administrative decision making. Risk categorization is displayed in the following manner (Table 1).

Number of cases	Risk category	Color on the map
No cases	Low	No color
1-4	Moderate	Green
≥5	High	Red

Table 1: Risk category of Divisional Secretariat Divisions by the number of cases reported

Buffer zones: Once a risk area is identified, a buffer zone (which is usually a 1km radius from the risk area) can be highlighted on the map. A buffer zone radius is customizable for the decision makers**.** The areas in the buffer zones can be more vigilant of risk of spreading infection. The decision makers can allocate more resources to the risk areas and buffer zones for disease control and prevention measures.

Comparisons: The web application allows comparisons of epidemiological information among different geographical areas and different time periods,

Global burden of COVID-19 infection: This package provides a direct link to Johns Hopkins university website, which allows comparisons of local data with global data.

3.2 Data management

Source of data WP-COVID receives data mainly from 2 sources

1. Data is collected from directly as a consolidated return emailed to WP-COVID center located at the Provincial Directorate of Health Services- Western Province as a Microsoft Excel spreadsheet. This information is manually translated to application readable data by a data entry operator.

2. Information collected by the Public Health Inspectors (PHI) s of Western Province provide data through the MOHs and RDHSs to the PD office.

Data Validation – Data validation will be carried out by the PHI on site. Collected data is checked by a Medical Officer of Health, Regional Epidemiologist and the Regional Director of Health Services before sending to the system. The data entry operator at the system will again validate data before entering into the system.

Data storage: Epidemiological data will be encrypted and stored in a secure database for future analysis.

Data accuracy: Data accuracy will be maintained at 43 levels. Firstly, data accuracy will be checked by the PHIs at the time of data collection. Secondly, data accuracy will be tested at the MOH level. Thirdly, data accuracy will be checked at the national level at the epidemiology unit. Fourthly, at the point of data enter, data accuracy will be tested.

Data analysis, presentation and summarization

Data is presented in colorful illustrative manner. The user/admin is capable of visualizing information in different formats based on the requirement. The software has integrated statistical analysis properties to perform simple summarizations.

The number of active cases, quarantine cases, safe patients can be summarized by the smallest GN division to the largest country level and by time. Patients can be traced by their names as this is a confidential package. Data can be retrieved as tables, graphs and maps.

3.3 Ethical Considerations

In a COVID like situation, where there would be a disaster like situation in a country, following ethical principles would be a huge challenge. As the package stores patient information by their names for ease of identification, this may lead to sensitive information breech. Therefore, the system should have security levels for identification information, or it should de-identify the patients by assigning them a number. The system did not obtain ethical clearance from any ethics review committee as this system was developed as an improvement to the existing disease surveillance system.

4. Mobile applications

Three mobile applications have been developing parallel to the development of the software package. The first mobile application is targeted at the public to increase public awareness. The public is able to see the geo-map with risk areas but not sensitive patient related information.

The second application is meant for the policy makers to identify the risks, with details of places with administrative importance (government institutions, religious places, schools, banks, private institutions, natural resources etc.). The third app is a mobile version of WP-COVD application for the epidemiologists and decision makers.

Results

Homepage

The homepage provides a summary of the present situation of the disease.

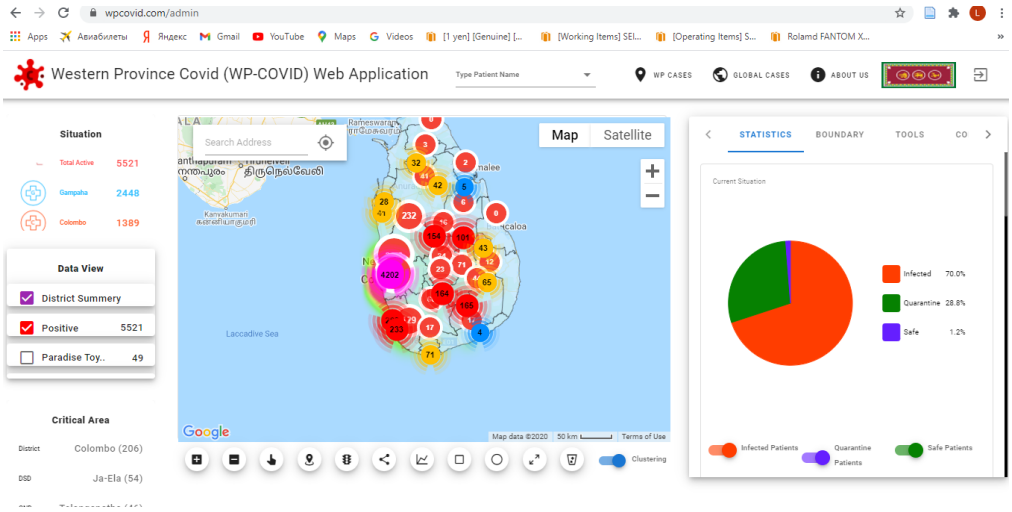


Figure 4: Dashboard of WP-COVID Web application illustrating real-time situation on the left top corner, selectable data view on the lest bottom, a Google Maps powered map on the middle showing the zoomed-out view of the entire island with prevalence of cases, those under quarantine and statistics page on the right with layers, filters and comparisons. The cases are marked in red, whereas those under quarantine are displayed in green. The locations of cases and their names can be searched by the admins. The total number of cases is displayed as at 1/11/2020

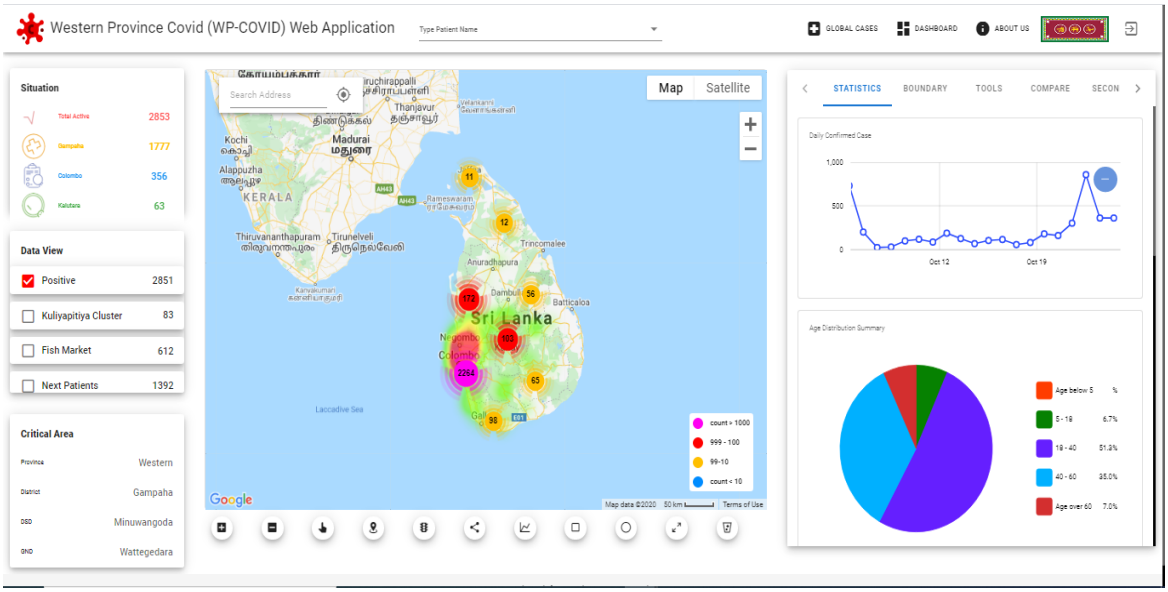


Figure 5: Illustrates incidence of COVID cases reported on each day of the month of October 2020. Age breakdown of cases are displayed in a pie chart.

Contact tracing

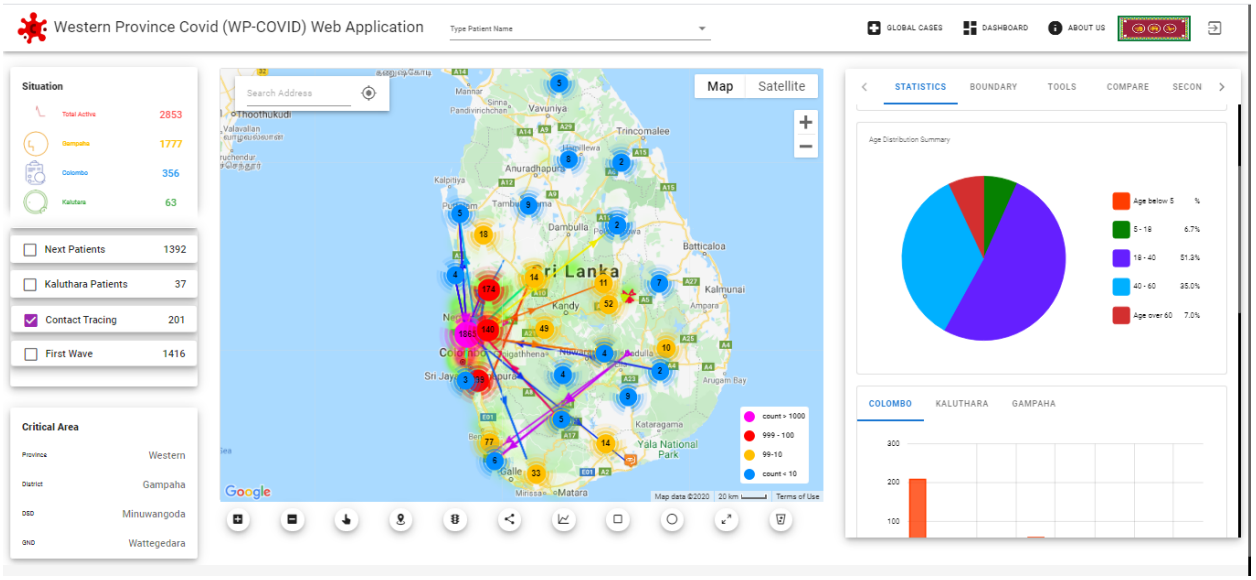


Figure 6 The package facilitates contact tracing by allowing display case's movement from one geographical location to another, thereby enabling the epidemiologists trace a case's possible contacts along his/her.

Risk categorization

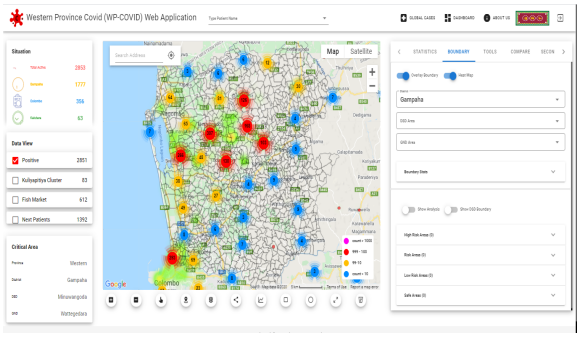


***Figure 7*:** Risk map of divisional secretariat divisions in Gampaha district

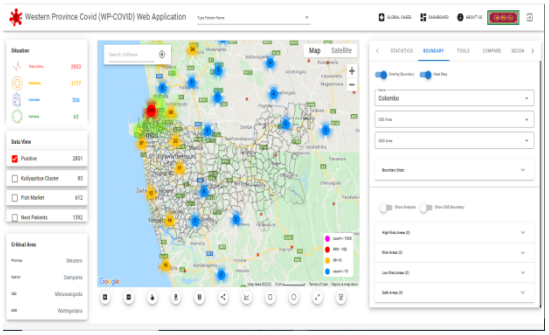


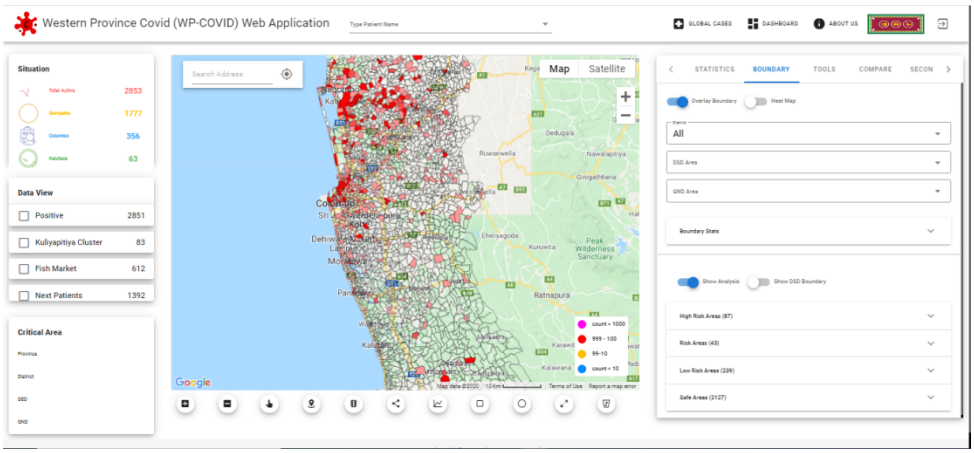
***Figure 8*:** Risk map of divisional secretariat divisions in Colombo

Figures 7 and 8: Divisional Secretariat Divisions are colored by the number of reported in each DSD as mentioned in Table 1. A DSD division is highlighted in red if the number of cases is ≥ 5 and so on. The active cases are removed from the map after 14 days considering that cases will not be active after that.

Grama Niladari Division Risk Map

Risk map has been developed with a GND layer to further sub classify the risk into a rather small cluster for ease of disease prevention and control activities. Similar to DSDs, GNDs with ≥5 cases will be highlighted red, while GNDs with 1-4 cases will be highlighted in pink.

Figure 9: *Risk map showing Grama Niladhari Divisions of Western Province by risk category*



Patient information

Patinet informaiotion have been entered in to the system along with name, age, sex, serial number (case number), GSD, DSD, MOH, Police Division, residential address, geo-location (latitide and longitude) and whether the patients belongs to the first or the second wave of COVID-19 outbreak.

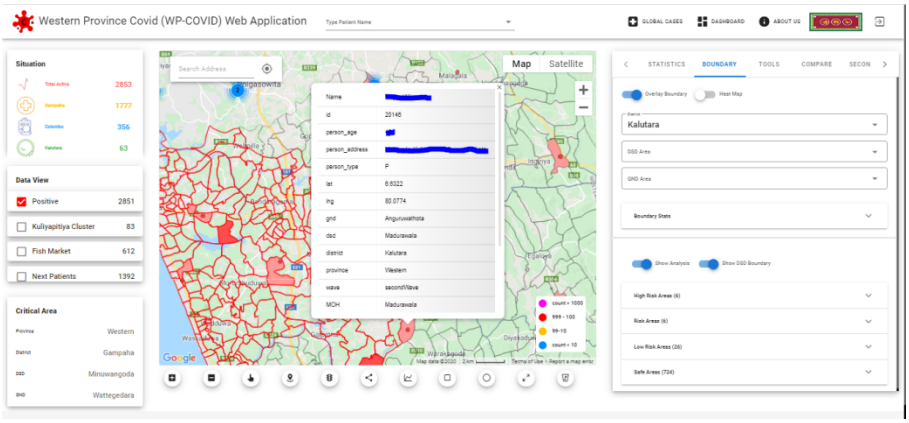


Figure 10 Patient information window is shown in the middle with details

Utilization of the package: At present this system is activity used in the Western province of Sri Lanka at the Provincial Directorate of Health Services. The system is shared with the Epidemiology Unit and Sri Lanka Army to carryout coordinated disease prevention activities**.**

Usage: The web application is being used at the Provincial Directorate of Health Services, Western Province.

5. Discussion:

WP-COVID web-based application provides excellent platform for epidemiologists to get information on ongoing epidemic and disease surveillance process by digitalizing an already existing basic concept of a spot map. When the application is electronic, rather than paper based much information can be creatively and usefully sorted in a very logical manner as adopted in this software by recording patient related information on geo-positions. Computer calculation and algorithms have been utilized to add to and remove them from the system in timely manner. Facilities like layering, linking to patient database, and integrated statistical analysis provide more flexibility in handling epidemiological data. Further it has to potential to be a universal system of disease surveillance.

The system's major weakness in inability to self-update. The system relies on information either sent by the epidemiology unit or the MOHs through the RDHSs. The flow of information gets slow at the time of data enter to the system as the data needed translation before entering into the system. Further, data gets delayed at several places such as at the MOH, RDHS and Epidemiology unit level before reaching the system. Patient information are verbally obtained by the PHI/medical staff and then transcribed to data-on-data routine data collection sheets. The accuracy of data could be challenged as the system does not provide an integrated system-specific data collection system.

As opposed to a traditional disease surveillance system, WP-COVID system is partly open to the public. Also, this is disease specific compared to routine surveillance system. Although not integrated to the existing software package, similar systems have been developed by the developer team for Dengue and Leptospirosis surveillance. The existing paper based, and electronic systems are well established in the present disease surveillance system of the Ministry of Health. Therefore, further testing may be necessary to see the system's capacity to handle a huge amount of data.

The ideal data collection method suggested by the developers of this system would be a handheld mobile device which will be capable of recording patient information with geo-locations. A commercially available mobile telephone would serve this purpose if held with the custody of the PHI. At present, though it is not surveyed, the developers assume that not every PHI has an Android or IOs powered mobile device. Therefore, any suggestion to a total electronic conversion of data collection needs prior survey and capacity assessment.

6. Recommendations

1. On-site data collection needs to be converted to electronic form through applying a mobile software to make use of the full functionality of a real-time disease surveillance system.
2. The poly makers and the users need more training and orientation into the new system
3. Immediate action is recommended as COVID-19 pandemic is a crisis situation.

4. There is a dire need for centralized/ state owned geo-information database linked to administration.

Please add a section on this project's implications on the health systems resilience.

Abbreviations:

DSD- Divisional Secretariat Division
GIS – Global Information System
GND – Grama Niladhari Division
MOH- Medical Officer of Health
PHI- Public Health Inspector
PDHS – Provincial Director of Health Services
RDHS – regional Director of Health Services
WP- Western Province

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