Short Review

How Modern Geographical Information Systems Based Mapping and Tracking Can Help to Combat Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2) Pandemic around the World and India

Running Title: GIS Based Mapping and Tracking to Combat SARS-CoV2

James T Devasia[1], Dr. Subitha Lakshminarayanan[2], Dr. Sitanshu Sekhar Kar[3]

[1]PhD, [2]Associate Professor, [3]Additional Professor

Department of Preventive and Social Medicine, Jawaharlal Institute of Postgraduate Medical Education and Research, Puducherry

Corresponding Author: James T Devasia

Email: **jamestd@gmail.com**

Abstract

In December 2019, a new virus of unknown etiology emerged in Wuhan city of Hubei Province, China causing a severe acute respiratory syndrome. The new virus originally called 'Novel Coronavirus 2019-nCoV', subsequently renamed to SARS-CoV-2 causes the disease named COVID-19. Despite China's effort to contain the virus within Wuhan, it spread across the continent and affected more than 200 countries within a short period and has put millions of lives and jobs in jeopardy. Geographical Information System (GIS) and its methods have been proven as an effective tool to control and monitor the preparedness of such pandemics in the past. This paper presents review of web-based real-time map-centric dashboards and mobile applications using modern GIS technologies, Global Positioning Systems (GPS), and Artificial Intelligence (AI) in order to collate the data from different validated sources to map and disseminate information on the disease spread, risk mapping, contact tracing, and to keep track of COVID-19 pandemic across the world and India.

Keywords: GIS, Geographical Information System, COVID–19, SARS-COV-2, Coronavirus, Mobile apps, Dashboard, Pandemic, India

Introduction

The first case of Novel Coronavirus 2019-nCoV was reported in Wuhan city of Hubei Province, China in December 2019; later it was renamed as – SARS-CoV-2 which causes Severe Acute Respiratory Syndrome (SARS). Coronavirus is a group of viruses that can cause mild to lethal illnesses causing respiratory tract infections. The first such virus was found in domesticated chickens in 1930 as the infectious bronchitis virus (IBV) [1], and the first human coronavirus was isolated in 1960 [2,3]. Unlike other coronavirus linked illness, two outbreaks namely: a) an

outbreak of atypical pneumonia in Guangdong Province, China in November 2002, also known to be the first known lethal illness of SARS [4–6], and b) Middle East respiratory syndrome (MERS), also known as camel flu, caused by the MERS-coronavirus (MERS-CoV), originated in Arabian Peninsula in 2012 [7–9], had raised the alarm globally. Coronavirus disease COVID-19 that emerged in Wuhan spread extremely fast across the globe [10–12] as compared to the 2003 and 2012 SARS and MERS outbreaks. Based on epidemiology of this disease, on January 30, 2020, World Health Organization (WHO) declared SARS- CoV-2 outbreaks as Public Health Emergency of International Concern (PHEIC) [13].

Longley et al., in their book Geographic Information Systems, have defined "Geographic information systems are a special class of information systems that keep track not only of events, activities, and things, but also of where these events, activities, and things happen or exist." The systems consists of human resources, procedures, software, networks, and hardware for input, capable of analyzing and displaying spatially referenced data [14].

Geographical Information Systems (GIS) and its methods have proven to be a powerful tool in SARS and MERS outbreaks in order to visualize progression of these diseases, to understand spatial evolution and temporal changes of diseases clusters over time, and to learn the spatial distribution of suspected cases (for example, Corda's World Map of SARS depicts each country affected by SARS corona virus in choropleth maps Figure:1 [15]. These methods also allow the spatial contact tracing of a suspected case, spatial prediction of disease transmission and risk mapping to understand the epidemiology of the diseases [15–20].

Conventional mapping of disease outbreaks and their locations was done effectively in the 1854 London cholera outbreak [21], and the 1694 containment of plague in Italy [22]. Modern technologies for robust mapping and spatial analysis of health indices started in 1960. In 2016, the U.S. Centres for Disease Control and Prevention, used web based GIS technologies from Environmental Systems Research Institute (ESRI) to track the Zika virus outbreak in USA [23,24].

Interactive web-based maps play a crucial role in outbreak control, offering real-time or near real-time map updates, incorporating multiple data sources from different countries, data triangulation of variety of sources, and offer wider dissemination to larger audiences across the globe. This paper illustrates how modern GIS technologies are being used to tackle the COVID-19 outbreak in the world and in India.

Global Initiatives of Web-Based COVID-19 Tracking

The perils of SARS-CoV-2 outbreak have traversed across the globe, risking people's lives. However, this COVID-19 pandemic did create extensive misinformation regarding the illness [25]. This led the authorities to channel exact and accurate information regarding SARS-CoV-2 coronavirus. Globally many organizations, universities, and government joined hands to develop a combined GIS, Artificial Intelligence (AI), and big data-enabled analytics dashboards to track and map the dynamics of COVID-19 pandemic. The majority of these dashboards use many data sources across the world and update their information in real-time or in near real-time by AI-powered technology [26].

COVID-19 Dashboard by the Center for Systems Science and Engineering (CSSE) at Johns Hopkins University (JHU)

The dashboard was developed by Lauren Gardner, Associate Professor in the Department of Civil and Systems Engineering at Johns Hopkins Whiting School of Engineering, and her team. The dashboard debuted on January 22, 2020, and now has one billion views per day (Figure: 2) [27]. Total confirmed cases by country get updated on left side of the dashboard and total deaths, total recovered, and total tests conducted in the USA are displayed on right side of dashboard. The bottom of the dashboard depicts a link to the article in Lancet [28], blog[29] and downloadable dataset in GitHub [30]. ESRI living atlas team supports the GIS components, with striking black and red world map [31]. Data sources for JHU CSSE dashboard are: World Health Organization [32], Centre for Diseases Control and Prevention (CDC) [33], European Centre for Disease Prevention and Control (ECDC) [34], National Health Commission of People Republic of China (NHC) [35], DXY.DX Doctor (DXY) [36], 1point3acres [37], Worldometers.info [38], BNO [39], and the COVID Tracking Project [40]. Anyone with an active internet connection and with few clicks can learn from this resource. JHU dashboard also provides a mobile version [41] as well as future maps [42].

WHO Coronavirus (COVID-19) Situation Dashboard

WHO has released a key update about COVID-19 situation dashboard as COVID-19 initiative with a clean and modern user interface with several data visualizations (Figure: 3) [43]. This update allows users to get information on confirmed cases and deaths on daily statistics. At the top, the user can filter the country or region, while the left side dropdown allows to choose cases or deaths. Case and deaths are shown in a heatmap style bubble map. Several interactive bar charts show confirmed cases and deaths over time, case comparisons of WHO regions, daily cases by WHO regions, and the highest cases by country or territory or area displayed by line charts. The Explorer section on top right corner of the web page helps to understand the complex dataset for easy access and use. User can change the Y-axis, X-axis and Z-axis with the drop-down options from top left, bottom center and top right section of the bubble graph plot area respectively. Country filter options are provided just below to Z-axis selection. By default, explorer portrays world-wide cumulative case vs cumulative deaths with depth field is set to population. The dashboard is maintained by the WHO Health Emergency Team and the source of data on this dashboard is cases and deaths reported to WHO by every country.

HealthMap by Boston Children's Hospital

Epidemiologists, researchers, and software engineers at Boston Children's Hospital developed a respiratory alert system (Figure: 4) [44, 45]. HealthMap was founded in 2006 for real-time surveillance of public health threats using online sources. The dashboard also provides alerts about the Ebola outbreak, Avion influenza, measles, and vector-borne diseases. Users can also search using keywords based on diseases, location, source, dates, and species.

Prominent universities, international non-governmental organizations (NGOs) have also developed web-based dashboards for tracking coronavirus infections worldwide, some of the notable dashboards are Novel Coronavirus (COVID-19) Infection Map by University of Washington [46], The Kaiser Family Foundation's COVID-19 Coronavirus Tracker [47], Corona Board's COVID-19 Dashboard [48] and Microsoft corporation's Bing COVID-19 Tracker [49]. Table 1 illustrates the list of top coronavirus dashboard which updates real-time parameters of this disease.

Indian initiatives of COVID-19 Tracking Web-Based Dashboards

COVID-19 pandemic has risen a tremendous need for Information Communication Technologies (ICT) in health systems across India. This includes mobile and web-based coronavirus situation dashboards, surveillance of infection, contact tracing of suspected or confirmed cases, monitoring effective home quarantine, efficient resource allocation, and managing response and communications. According to a news article published in Nature, India heavily depends on people's power to combat with COVID-19 pandemic [50]. Along with national organizations like Ministry of Health and Family Welfare (MoHFW) and National Disaster Management Authority (NDMA), many states have developed their own dashboards as well using data from various validated sources.

COVID-19 INDIA by Ministry of Health and Family Welfare (MoHFW)

COVID-19 INDIA dashboard, developed and hosted by National Informatics Centre (NIC) (Figure: 5) [51], offers a clean user interface and an interactive chart and map display of coronavirus infections updated on daily basis. Top right side of the dashboard gives the snapshot of 'Active Case', 'Cured/Discharged', 'Deaths' and 'Migrated' in four colored boxes. On left side, choropleth maps with 'Count' as legends, depicts state wise positive cases, cured, and total death due to COVID-19. Hovering over the maps displays a pop-up box with UpToDate status of COVID-19 state name, current positive, cured and deaths. The left side of the dashboard offers trend analysis of active cases, cured cases, deaths, and differential number of cases as compared to the previous day of all states. The bar graph at bottom of the dashboard depicts state-wise COVID-19 Cases, Cured/Discharge/Migrated and Deaths.

India - COVID 19 by National Disaster Management Authority (NDMA), GoI (India)

In March 2020, NDMA in assistance with ESRI launched the COVID tracking dashboard (Figure: 6) [52], which helps to keep track of the number of cases reported in the country. The dashboard also portrays the world statistics of coronavirus cases as well. On the left side, an interactive pie chart depicts the number of confirmed cases by states. Below this graph, another line graph showing trend analysis of cumulative confirmed, recovered, and deaths cases between two months is displayed. The right side of the dashboard presents state-wise confirmed, recovered, and deaths due to COVID-19 and additional tabs report date wise confirmed, recovered, and deaths due to coronavirus.

Besides these, the dashboard also displays a map where users can track the most affected part of the country due to COVID-19. It also gives information regarding the list of hospitals, testing laboratories, and quarantine information of suspected cases. The website also brings out the latest news from various credible sources and displays tweets from NDMA's twitter handle. One can update oneself with current scenario of COVID-19 pandemic spread in India through this dashboard.

Many states have also developed GIS incorporated dashboard with the credible data source to track COVID-19. COVID-19 Battle by Kerala [53] and COVID-19 Dashboard by Odisha [54] exhibit district level choropleth map of active cases. Clicking over the map, one can have access to information regarding district parameters such as: District name, Total Reported, Total Cured, Active Cases, and Death. PUNJAB COVID-19 DASHBOARD by Punjab Remote Sensing Centre, Ludhiana (India) [55] presents an interactive map with information sourced

from The United States Department of State (USDOS), ESRI, HERE Technologies, Garmin Ltd, Food and Agriculture Organization (FAO), National Oceanic and Atmospheric Administration (NOAA), and U.S. Geological Survey (USGS). Using the base map tool on top right corner of map, user can change the base map with available choice, and a rich layer source available in layer tool next to base map tool. There are twelve layers available and can be selected depending on the zoom level of the map. Using the drill-down functionality one can visualize street-level location of quarantine, positive cases and, location of designated COVID-19 hospitals. The left side donut chart and bottom bar chart dynamically changes as the map changes. The bottom of the web-page presents district-wise information in a multi-coloured bar chart. By default, the chart exhibits only 'Confirmed Cases'. The arrow below the chart leads us to some demographic information of the district and district hospitals that include: Home Quarantined Cases, Hospitalized Cases, Recovered Cases, Death Case, Isolation Beds, Total No. of Ventilators, and Total No. of ICU Beds. Date wise 'Confirmed Cases' and 'Date-wise Sample Collection Results' are shown in line chart. The bottom right of the dashboard shows the test results in a pie chart. K-GIS: COVID-19 Geospatial Portal by Karnataka developed and maintained by Karnataka State Remote Sensing Applications Centre (KSRSAC) uses street level map to illustrate COVID-19 situation. The portal also exhibits six different thematic views, views of the containment area, and view of the hotspot. With a few clicks, one can get information on number of cases in the hotspot and the wards, villages, and taluk affected in the COVID-19 epidemic. The portal also provides additional information on X, Y coordinates of the positive cases along with address of the cases, date of declaration, and current status [56]. The complete list of dashboards that can track the COVID-19 in India is given in Table 2.

Mobile Technology Use in India to Monitor and Control COVID-19

According to Statista, a German-based online statistical portal for market data, reported the number of smartphone users in India was projected to be 373.88 million in 2019 [57]. The Chinese government claims effectiveness of smartphone-based interventions in controlling and tracking the spread of COVID-19 [58, 59]. The Government of India, launched the Aarogya Setu App on 2nd April 2020 and it turned out to be the world's quickest app to cross 50 million downloads. Aarogya Setu app [60] has been developed by the NIC under the Ministry of Electronics and Information Technology (MeitY) and is available in Android and iOS platforms supporting 11 languages. This contract tracing feature uses a smartphone's Bluetooth technology and GPS systems to alert users within Bluetooth proximity of COVID-19 patients[61].

Table 3 lists the official apps developed to battle with the COVID-19 pandemic. Contact tracing and tracking of COVID-19 patients use smartphones Global Positioning System (GPS) and Geo-fencing technology. Mobile apps also deliver critical information to the citizens regarding the updates of cases and other useful information during the pandemic times. Chhattisgarh (CG Covid-19 ePass [62]) and Rajasthan (RajCop Citizen [63]) use mobile apps to issue e-Pass during the lockdown period. Karnataka (Dasoha 2020 Food Delivery [64]) and Uttarakhand (Jan Aapurti – Uttarakhand [65]) use apps to deliver food for the needy and groceries to the citizens. Maharashtra (Mahakavach [66]), Gujrat (SMC COVID-19 Tracker [67]), Tamil Nadu (COVID-19 Quarantine Monitor Tamil Nadu (Official) [68]) and many other states use apps to track the COVID-19 suspected people to curb the spread of the disease.

Summary

Map centric dashboards and mobile applications are popular tools and methods to disseminate COVID-19 updates to a wider population nationally and globally. Globally there are around thirteen dashboards that are maintained by universities and global development partners which use GIS map sources are ESRI living atlas, Google, and other maps as prime interface. In India there are around twenty-two dashboards, with eighteen of them are supported either by central or state government. Fourteen dashboards use GIS functionality to disseminate COVID-19 information. Around 42 mobile apps in India supported by government are used to monitor, and track of positive coronavirus cases and home quarantine people. Other services offered by these mobile apps connect people with the government for COVID-19 information, helpline services, and e-Pass during lockdown period.

Conclusion

Geographical Information System centred web-based dashboards have taken mainstream focus in COVID-19 tracking and preparedness in a pandemic situation. Enhanced data sharing policies, real-time information support, and use of modern GIS technologies and Artificial Intelligence (AI) aides in critical decision making to the authorities. GIS-based data dissemination is widely popular in ancient and modern medical science, especially in epidemiology and infectious disease outbreaks. Communication through modern smartphone technologies would protect the people, families, and their communities. The use of GIS technologies and its methods is a real problem-solving tool in the whole cycle of containing infectious disease outbreaks and improve the overall health system.

Table: 1 COVID-19 Maps & visuals (Global)

Dashboard Name	Organization	Link/ References
COVID-19 Situation Dashboard	WHO	https://covid19.who.int
COVID-19 Dashboard	JHU CSSE	https://coronavirus.jhu.edu/map.html
COVID-19 Dashboard	Coronaboard	https://coronaboard.com/global/
COVID-19 Tracker	Microsoft	https://www.bing.com/covid
COVID-19 Infection Map	University of Washington	https://hgis.uw.edu/virus/
COVID-19 Data Hub	Tableau	https://www.tableau.com/covid-19-coronavirus-data-resources
COVID-19 Maps and Analytics	SharedGeo	https://uscovid-19map.org
COVID-19 Outbreak timeline map	HealthMap	https://www.healthmap.org/covid-19/
COVID-19 Surveillance Dashboard	University of Virginia	https://nssac.bii.virginia.edu/covid-19/dashboard/
COVID-19 Cases	CDC	https://www.cdc.gov/coronavirus/2019-ncov/cases-updates/cases-in-us.html
COVID-19 Coronavirus Tracker	KFF	https://www.kff.org/global-health-policy/fact-sheet/coronavirus-tracker/
Health Map	HealthMap	https://healthmap.org/en/
ESRI Story Maps	ESRI	https://storymaps.arcgis.com/stories/4fdc0d03d3a34aa485de1fb0d2650ee0

Table: 2 COVID-19 Maps & visuals (India)

Dashboard Name	Organization /State	Link/ References
GIS centric interactive dashboards		
COVID-19 INDIA	MoHFW GoI (India)	https://www.mohfw.gov.in/index.php
India - COVID 19	NDMA, GoI (India)	http://gis.ndma.gov.in/arcgis/apps/sites/#/data
PRediction and Assesment of CoRona Infections and Transmission in India	IIT Delhi	http://pracriti.iitd.ac.in
Punjab State	Punjab	http://gis-prsc.punjab.gov.in/covid/Punjab_level.aspx
PUNJAB COVID-19 DASHBOARD	Punjab	https://punjabcovid19.maps.arcgis.com/apps/opsdashboard/index.html#/445965eec8744f5ab496a5d48e711e92
COVID-19	Ideas2IT	https://covid-19.ideas2it.com
K-GIS: COVID-19 Geospatial Portal	Karnataka	https://kgis.ksrsac.in/covid/
Coronavirus Monitor	HealthCheck	https://corona.health-check.in
COVID-19 Battle	Kerala	https://dashboard.kerala.gov.in
COVID-19 PUNJAB HEAT MAP	India & Punjab	https://dronamaps.com/corona.html#/
COVID-19 Tracker	Microsoft	https://www.bing.com/covid/local/india
COVID-19 Dashboard	Odisha	https://health.odisha.gov.in/covid19-dashboard.html
COVID-19 Dashboard - Gujarat	Gujarat	https://gujcovid19.gujarat.gov.in
COVID-19 Dashboard	Madhya Pradesh	https://mapit.gov.in/covid-19/Covid-Dashboard.aspx
Non-GIS interactive dashboards		
Covid-19 Puducherry	Puducherry	https://covid19dashboard.py.gov.in
OFFICIAL DASHBOARD	Karnataka	http://covid19dashboard.karnataka.go

		v.in
COVID-19	Meghalaya	http://meghalayaonline.gov.in/covid/
COVID19 Dashboard	Nagaland	https://covid19.nagaland.gov.in
Non-GIS Static dashboards		
Control Room Information Centre for COVID-19	Arunachal Pradesh	http://covid19.itanagarsmartcity.in/covidstatus.php
COVID-19 Guidelines, Advisory, Dashboard	Tripura	https://covid19.tripura.gov.in/Default.aspx
COVID-19: Andhra Pradesh	Andhra Pradesh	http://hmfw.ap.gov.in/covid_dashboard.aspx
Covid-19: Dashboard, Traveller Reporting and Volunteer Registration	Jammu & Kashmir	https://baramulla.nic.in/covid-19-reporting-and-info/

Table: 3 COVID -19 Mobile Apps (India)

App Name	State	Purpose	Features
Aarogya Setu [60]	NIC GoI	Contact tracing, COVID-19 alert	COVID alert, contact tracing, COVID information services, self-screening
Mahakavach [66]	Maharashtra State Innovation Society	Contact tracing & tracking of COVID home quarantine	Contact tracing, tracking home quarantine
Covid Locator [69]	Goa	Home Quarantine Monitoring/tracking	Tracking home quarantine (map), COVID information services, Dashboard (India), heat map of home quarantine, help line services
Fight Covid [70]	Maharashtra	Home Quarantine Monitoring/tracking	Tracking home quarantine (map) and selfie, Reports
COVID CARE [71]	Arunachal Pradesh	Contact tracing & tracking of COVID home quarantine	Contact tracing, tracking home quarantine
UP Self-Quarantine App [72]	Uttar Pradesh	Home Quarantine Monitoring/tracking	COVID information services, self-registration (travel history, symptoms, and test results), tracking home

			quarantine
COVID-19 Quarantine Monitor Tamil Nadu (Official) [68]	Tamil Nadu	Home Quarantine Monitoring/tracking	Tracking home quarantine, Live location tracking and alerts
SMC COVID-19 Tracker [67]	Surat Municipal Corporation (Gujrat)	Contact tracing & tracking of COVID patients	Track people with travel history (abroad, interstate) and direct contact with COVID-19 case, help line services, health monitoring of people who are in their database.
Telangana Covid19 Tracker [73]	IT Cell Telangana State Police (Telangana)	Home Quarantine Monitoring/tracking	Tracking home quarantine
House Quarantine AP Police [74]	Andhra Pradesh Police Department	Home Quarantine Monitoring/tracking	Tracking home quarantine
Corona Mukt Himachal [75]	Himachal Pradesh	Home Quarantine Monitoring/tracking	Tracking home quarantine
Quarantine Watch [76]	Karnataka	Self-reporting Home Quarantine	Self-reporting, tracking home quarantine, health monitoring of home quarantine people
Corona Watch [77]	Karnataka	Tracking of corona patients	Location and movement history of corona patients (last 14 days), COVID information services, help line services
COVID-19 West Bengal Government [78]	West Bengal	Monitor & control corona virus	Tracking home quarantine, COVID information services, help line services
MP COVID RESPONSE APP [79]	Madhya Pradesh	COVID-19 reporting	Dashboard (Madhya Pradesh and India), COVID reporting, COVID information services, donation to CM relief fund.
GCC – Corona Monitoring [80]	Greater Chennai Corporation (Tamil Nadu)	COVID-19 reporting	COVID reporting

Kavach [81]	Chhattisgarh	COVID alert	Dashboard (Chhattisgarh, India, Global), self-screening,
Odisha COVID Dashboard [82]	Odisha	COVID Dashboard	Real time dashboard
COVA Punjab [83]	Punjab	Connect people with government	Dashboard (Punjab, India & global), self-screening, COVID information services
COVAAS [84]	Assam	Connect people with government	District wise dashboard, e-pass, 104 helplines, donation to CMRF-Assam, COVID information services, Volunteer opportunities
Jan Sahayak - HelpMe App [85]	Haryana	Connect people with government	Welfare services, access to e-learning resources, Volunteer opportunities
RajCop Citizen [63]	Rajasthan	Connect people with government	Lockdown pass, help line services, report crime or complaint, view FIR, search vehicle, background check, route services, women safety features
Uttarakhand CV 19 Tracking System [86]	Uttarakhand	Connect people with government	COVID information services
RajCovidInfo [87]	DoIT&C (Rajasthan)	Connect people with government	COVID information services, help line services, location-based alerts
GoK Direct – Kerala [88]	Kerala	Connect people with government	COVID information services
mCOVID19 [89]	Mizoram	Connect people with government	COVID information services
NMC COVID-19 [90]	Nashik Municipal Corporation (Maharashtra)	Connect people with government	COVID information services, COVID case reporting
COVID-19 Odisha [91]	Odisha	Connect people with government	COVID information services
T COVID'19 [92]	Telangana	Connect people with government	COVID information services, help line services, tele-medicine

Trackmetic – (Niramoy) by Morigaon Police, Assam [93]	Morigaon Police (Assam)	Connect people with government	COVID information services
COVID-19 Care Tamil Nadu – (Official) [94]	Tamil Nadu	Connect people with government	Self-screening, telemedicine request, real time COVID-19 report and tracker (map), COVID information services, help line services
Jaano [95]	Districts Administration (Punjab)	Connect people with government	COVID information services, find delivery services
Haryana Sahayak [96]	Haryana	Connect people with government	Dashboard, COVID information services, self-screening, e-Pass, volunteer opportunities
COVID Care Delhi [97]	Delhi	Connect people with government	Self-screening, guidelines, help line services, ration, e-pass and hunger/shelter relief centres.
CG Covid-19 ePass [62]	Chhattisgarh	e-Pass during lockdown	e-Pass
Dasoha 2020 Food Delivery [64]	Karnataka	Food delivery	Food delivery
Jan Aapurti – Uttarakhand [65]	Food and Civil Supplies Department (Uttarakhand)	Food/groceries delivery	Food/ grocery delivery
Ayush Kavach [98]	Uttar Pradesh	Information and precautions to protect Covid-19	Healthy life style awareness, AYUSH information services, YOGA sessions, help line services
West Bengal Emergency Fund [99]	West Bengal	West Bengal State Emergency Relief Fund	Donation to West Bengal State Emergency Relief Fund
Test yourself Puducherry [100]	Innovaccer Inc	Self-evaluation	Self-screening
Test yourself Goa	Innovaccer Inc	Self-evaluation	Self-screening

[101]			
nCOVID-19 Nagaland – Visitors App [102]	Nagaland	Applications for visitors to Nagaland	COVID information services, help line services, contact tracing, home quarantine, visitor pass, community reporting
Jharkhand Sahatya [103]	Jharkhand Space Application Centre (Jharkhand)	Tracking migrant worker	Geo-Fencing (200km), capture migrant worker information lined with PFMS portal, Dashboard for migrant worker information, SMS facility
Ayush Sanjivani [104]	Ministry of AYUSH, GOI	Research	Data collection tool to find the measures taken by public during COVID-19. Data will be analysed to find out practice of AYUSH interventions.
COVID19 Feedback [105]	MeitY, Government of India	Research	Collecting feedback from individual who underwent COVID-19 treatment.

Figure: 1 World SARS Cases by July 2003 [15]

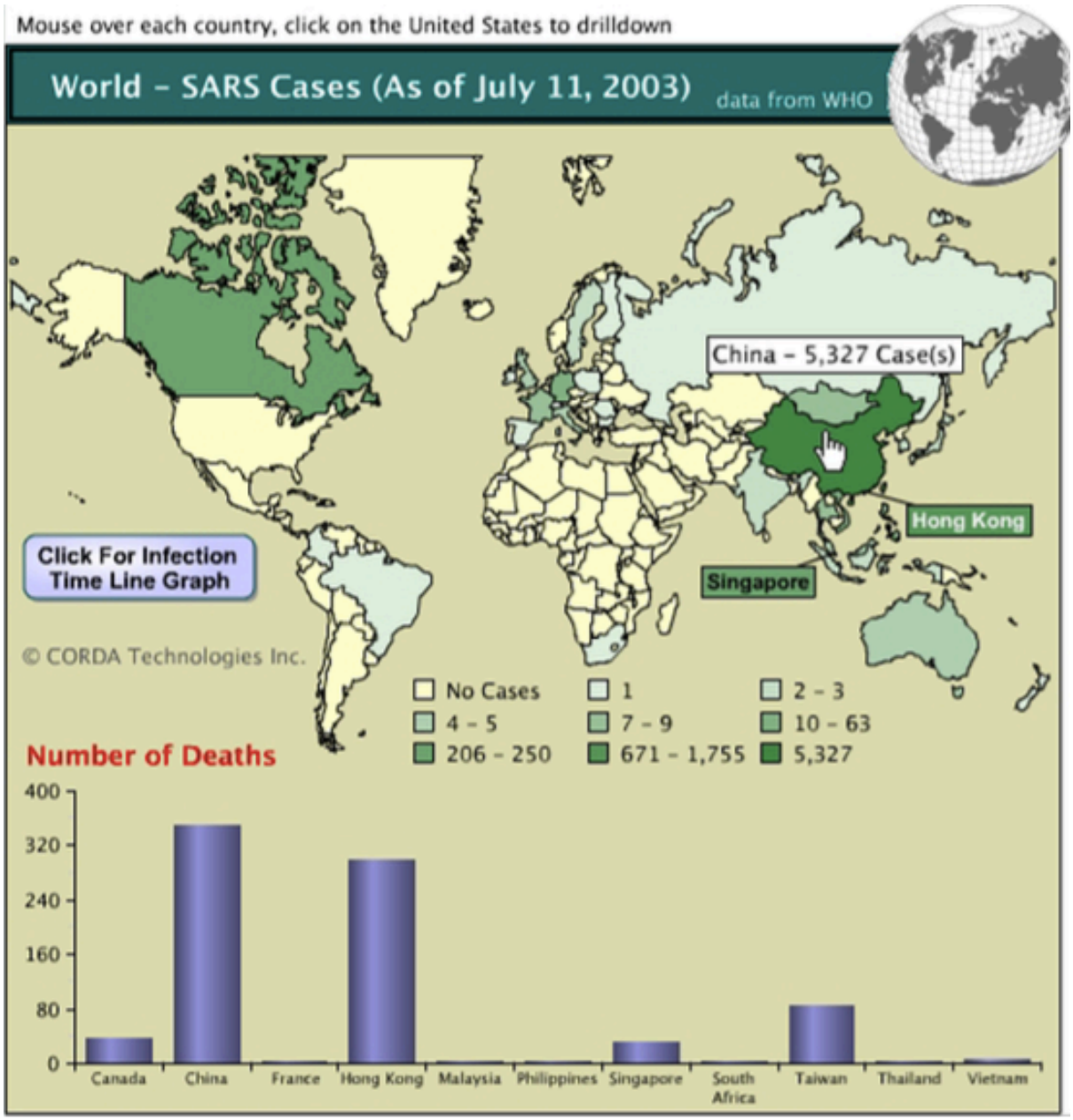

Figure 1
Corda's world map of SARS. Web browser screenshot by this author of Corda's world map of SARS displaying data for each country affected by SARS as of 11 July 2003 http://www.corda.com/examples/go/map/sars.cfm. As the mouse moved over a country, a ToolTip appears with the cumulative number of reported cases. An accompanying graph shows SARS deaths by country. Users can also drill-down into the United States map to view how many cases have been reported in each state.

Figure: 2 COVID-19 Dashboard by the Center for Systems Science and Engineering (CSSE) at Johns Hopkins University (JHU). Screenshot date: 25th April 2020 [27]

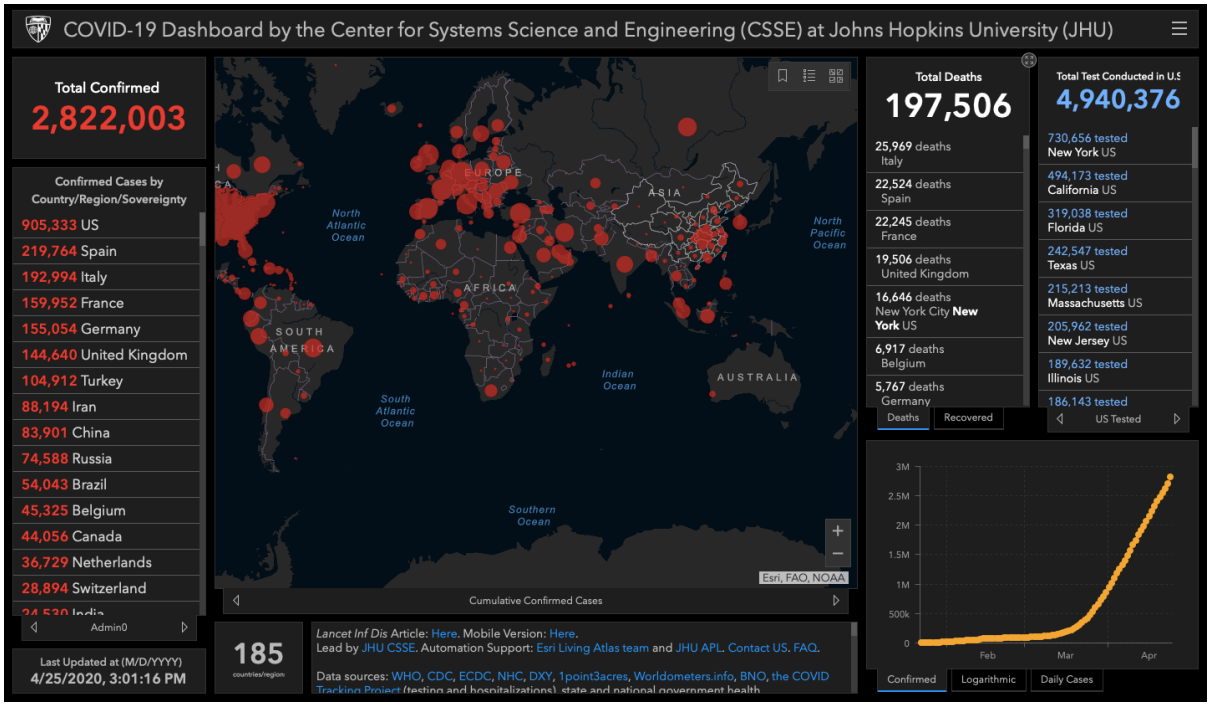

Figure: 3 WHO Coronavirus (COVID-19) situation Dashboard. Screenshot date: 26th April 2020 [43]

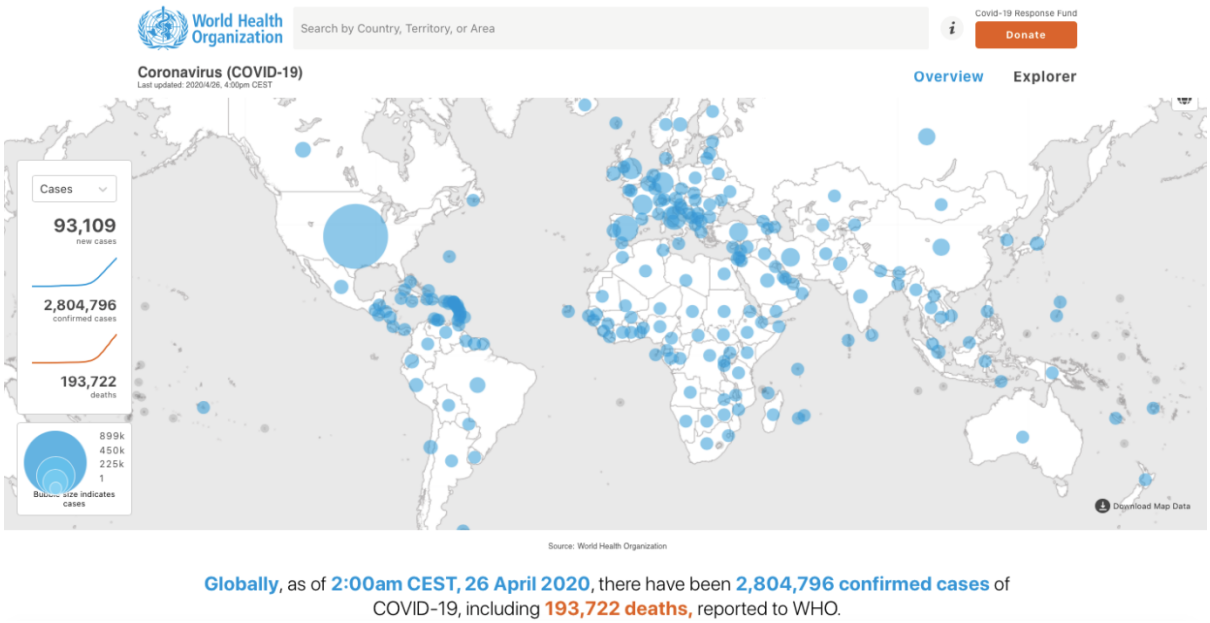

Figure: 4 HealthMap by Boston Children's Hospital. Screenshot date: 26th April 2020 [44]

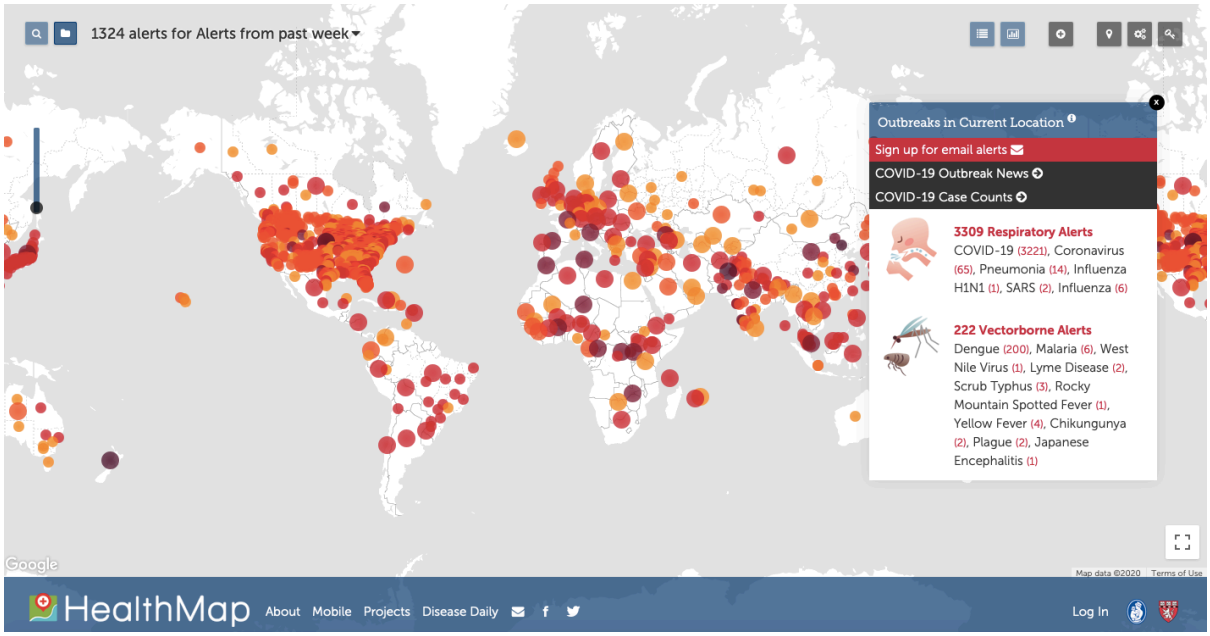

Figure: 5 COVID-19 INDIA by Ministry of Health and Family Welfare (MoHFW). Screenshot date: 27th April 2020 [51]

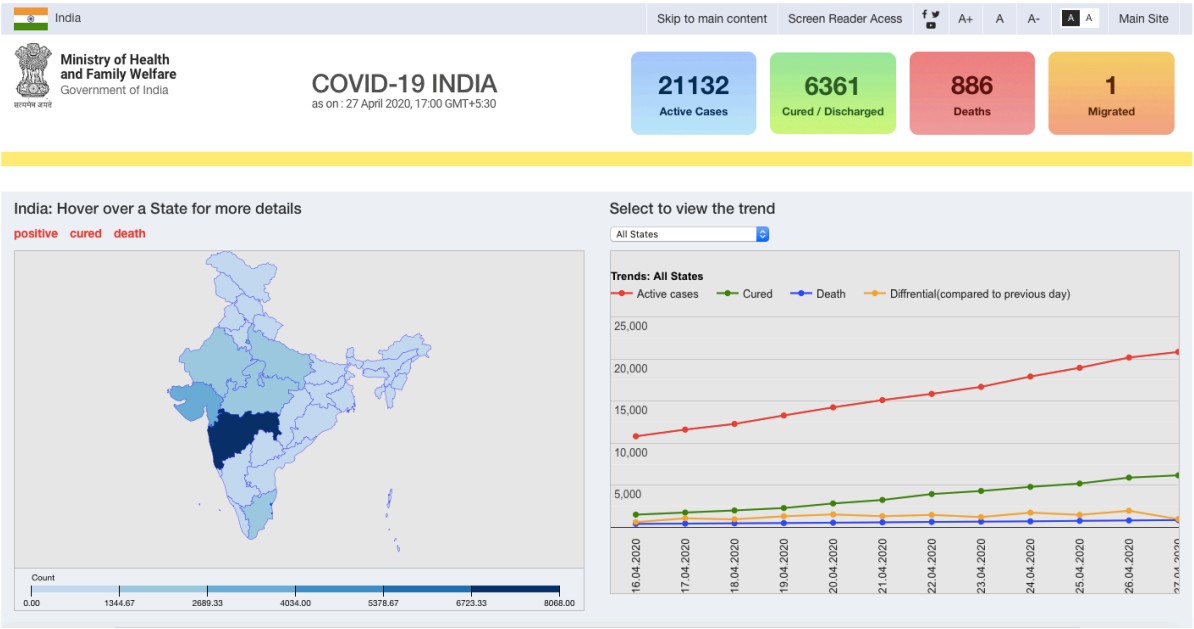

Figure: 6 India - COVID 19 by National Disaster Management Authority, GoI (India). Screenshot date: 26th April 2020 [52]

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