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# Monitoring Coronavirus COVID-19/SARS-CoV-2 Pandemic using GIS Dashboard: International and Indonesia Context

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## Abstract

COVID-19 pandemic event requires a rapid response from various organizations at the international and national levels. One important response is the provision of information sharing facilities and monitoring of the spread of cases around the world, JHU CSSE developed the Dashboard in January 2020 and followed by WHO the same month for the WHO COVID-19 dashboard. Both dashboards have distributed information as expected by the user with their respective pros and cons. JHU CSSE Dashboard provides faster information with good access to mobile device users even though the display and color selection are less attractive. Information on the WHO COVID-19 Dashboard is often late but with more data appearances and variations and comparisons between countries can be made. In the Indonesian context, ESSC for COVID-19 Geoportal as Esri Indonesia initiative has been developed with the support of data and information from various parties and developed with the principles of big data management which are fully supported by adequate spatial portal developer software from Esri. Particularly in Indonesia, there is not yet an adequate system to support spatial based decision making at the local level, therefore the development of a GIS dashboard to support provincial and district governments is highly recommended.

*Keywords:* pandemic, covid-19, monitoring, GIS dashboard, emergency spatial support centre

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## 1. Introduction

Several cases of pneumonia as a result of Covid-19 (at that time unknown) have been identified in the city of Wuhan Province Hubei China since the first week of December 2019 (1) and since January 20, 2020, these cases have reached four countries including China, Thailand and the Republic. Korea with a total of 282 cases. On that basis, starting January 30, 2020, WHO as a world health organization has designated the outbreak as a Public Health Emergency of International Concern (PHEIC) [2] and named it the new corona virus or covid-19 / SARS-CoV-2 as the cause of the outbreak on 11 February 2020 [3]. After that period, the outbreak spread to other parts of mainland China and other countries around the world quickly and widely, even though the Chinese government has made efforts to contain the massive covid-19 outbreak in the Hubei province [4]. According to the latest figures from COVID-19 Dashboard by the Centre for Systems Science and Engineering (CSSE) at Johns Hopkins University (JHU), Since it was first detected until now it has been confirmed, close to two million cases of coronavirus have been registered with a number of total deaths reached 114,290 people, 428,275 people recovered and globally has spread to 185 countries [5]. In the period in which the number and spread of the new SARS-CoV2 corona virus in China was the worst in December 2019-February 2020, in Indonesia there are still no reported the same cases. On March 2, 2020, the Indonesian government for the first time officially reported the first case of two patients out of a total of 85 infected with COVID-19 [6] and per April 13th, 2020 the country has reached 4,241 confirmed cases with 373 number of deaths, and 359 number of recoveries [7].

Unlike the SARS-CoV pandemic in 2002/2003 and MERS-CoV 2012-2014, cases due to the COVID-19 corona virus increased and spread very quickly where MERS-CoV took about two and a half years to infect 1000 people while SARS-CoV it only took about 4 months and COVID-19 reached the same number in just 48 days [4]. SARS-CoV with around 8000 confirmed human cases with 774 deaths or around 9.5% mortality rate and the 2012–2014 MERS-CoV pandemic claiming around 919 lives out of the total 2521 human cases or around 35% mortality

Communicating and visualizing the relationship between location and health using maps has existed since 1694 in outbreaks in Italy as well as services for tracking infectious diseases, such as yellow fever, cholera, and influenza during the 1918 pandemic, although it was only in the 1960s after the existence of GIS the ability to analyzing, visualizing, and detecting spatial patterns regarding disease rebounded dramatically [4]. A review of papers conducted by [8] on the GIS

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literature for health found that there were 248 out of 865 publications in the health sector including papers (28.7%) that focused on infectious diseases.

With a massive impact, a very rapid spread and has reached more than 185 countries in the world, it is needed a faster information technology tool. Geographical information system - GIS technology has played an important role in spatial analysis related to pandemics, so that epidemic prevention and control can be carried out, determining the spatial allocation of health resources, and detection of social sentiment [9]. According to [10], this is when map-based GIS dashboards become important. The dashboards allow citizens to grasp the latest situation and visualize the virus distribution pattern. The number of confirmed cases, cases still hospitalized for investigation and virus trends are available immediately.

The development of dashboards as a medium for health, evolved after Esri's operations dashboard was first released in 2013, as a tool for users to get a real-time operational view of people, services, assets and events. Previously available tools only had the capability and revolution in applied health geography via web-based tools [4]. In this case study will be analyzed the JHU CSSE and the WHO dashboard for international contexts based on relevant publications and rapid analysis from sourced from media content and actual implementation of various aspects of Big Data from the development of Emergency Spatial Support Center (ESSC) for COVID-19 Geoportal as one of Esri Indonesia's initiatives as a partner of the Indonesia National Disaster Management Agency (BNPB).

The structure of the paper is as follows: (1) The introduction section describing the world situation related to the number and distribution of COVID-19 and the role of maps, GIS and dashboards as tools and ways to communicate geographical information to users, (2) case description about JHU CSSE and WHO Dashboard and Emergency Spatial Support Center (ESSC) For COVID-19 Geoportal as discussion of GIS dashboard in a national context, (3) discussion and evaluation of the pros and cons of the existence of the dashboard at the international or national level and finally construct (4) conclusion with providing outline about current conditions regarding the availability of COVID-19 monitoring tools in the form of GIS Dashboard in international and national contexts and recommendations for the development of a more responsive dashboard for use in monitoring the COVID-19 pandemic change rapidly.

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## 2. Case Description

### 2.1 The World Health Organization Coronavirus (COVID-19) Dashboard

In line with the WHO mission to improve health, keep the world safe and serve vulnerable people, with measurable impacts on people at the country level [11] and in response to the COVID-19 pandemic, on January 26, 2020, launching the operation dashboard with ArcGIS platform for COVID-19, to map and monitor coronavirus cases and the total number of deaths by country and province of China, including detailed information about maps and data sources Fig.1 [12]. Measurements the dashboard performance using the Statshow, showed that (at the time of this paper) the WHO COVID-19 dashboard has a global rank of #199 which puts itself among the top 1,000 most popular websites worldwide. covid19.who.int rank has increased 501% over the last 3 months [13].

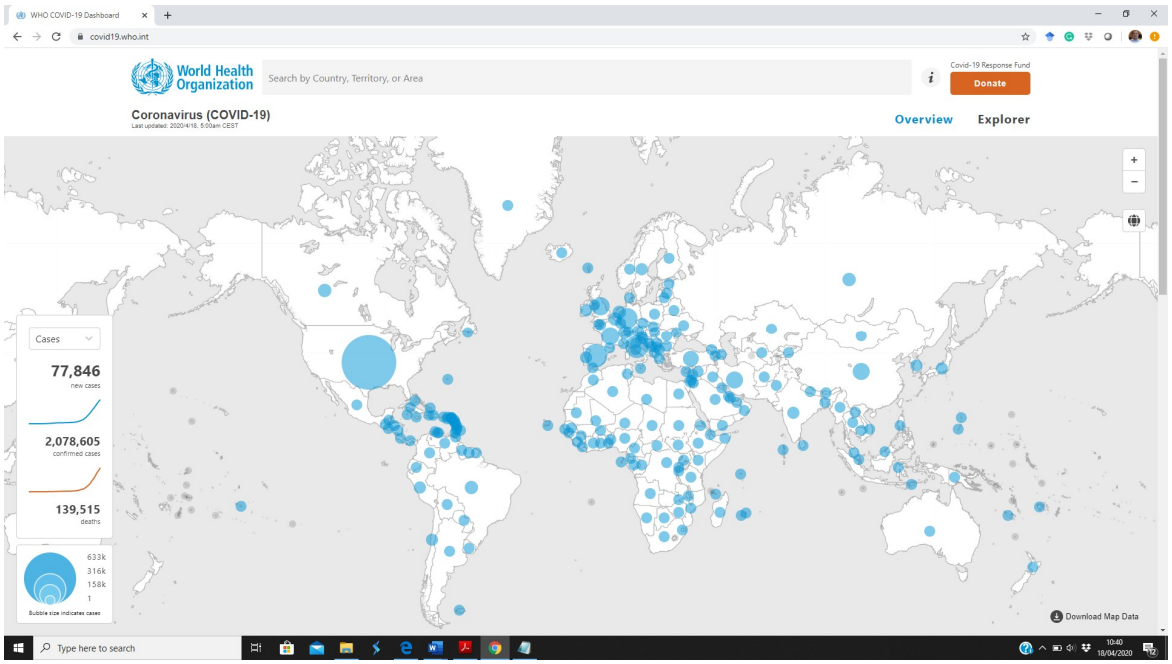


Figure 1. Display of the WHO COVID-19 current dashboard situation. Screenshot date: Feb 17th, 2020 [12]

According to [4], before mid-February 2020, the WHO dashboard and the Johns Hopkins University Center for Systems Science and Engineering (JHU CSSE) had some fundamental differences which each had a very different number of cases. The WHO dashboard reflects laboratory confirmed cases, while the JHU CSSE includes cases diagnosed using symptom sequences as well as chest imaging results. However, as of February 19, 2020, the two dashboards

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are being synced, showing the total of important similar cases. WHO updates the COVID-19 dashboard automatically using ArcGIS GeoEvent Server in order to support the ability to continuously update feature services data. WHO dashboard optimization measures include moving data from their own servers to the ArcGIS online service to get maximum benefit from Esri's content services [4].

On the WHO dashboard before mid-February 2020, the dashboard only reflects laboratory-confirmed cases and the number of deaths as well as location focus on pandemic source areas in mainland China. After that, the information on the dashboard continues to be developed along with the expansion of COVID-19 outbreaks throughout the world. This obedient dashboard includes a large amount of information including confirmed cases over time, deaths over time, case comparisons between WHO regions, daily cases by WHO regions and the highest cases by country, territory, or area [12].

### 2.2 Johns Hopkins University CSSE Dashboard

As a dashboard development by WHO, JHU CSSE developed a GIS dashboard using the ESRI platform to visualize and monitor the progress of the 2019 corona virus (COVID-19) cases globally and in real time since the pandemic began to be discovered and centered in the Hubei province of mainland China [14]. During a pandemic, the GIS dashboard is a reliable and reference source to monitor the spread of COVID-19 [5] both at the national and global levels. The dashboard first shared publicly on Jan 22, 2022, has a global rank of #1,575 which puts itself among the top 10,000 most popular websites worldwide. The rank has increased 205 % over the last 3 months and It reaches roughly 12,500,040 users and delivers about 20,000,070-page views each month [13].

The previous JHU CSSE COVID-19 Dashboard only described the location and number of confirmed COVID-19 cases as well as the number of deaths and recovered patients in all affected countries. The visualization of the numbers is intended to provide researchers, health authorities and interested parties with a user-friendly tool to monitor events as they occur. All data collected can be accessed free of charge via the GitHub repository as well as via the GIS dashboard and Esri Living Atlas [15]. The data sources used on the JHU CSSE dashboard come from various sources such as from WHO, CDC, ECDC, NHC, DXY, 1point3acres, Worldometers.info, BNO,

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COVID-19 Tracking Project, state and national government health departments and sourced from the local media. The data on recovered cases outside of China on the JHU CSSE dashboard are based on estimates of local media reports, national and local government official reports where available, in which case the reported figures are likely to be much lower than the actual figures. [16]. Data visualization in the first JHU CSSE dashboard on 22 January to 31 January 2020, the dashboard development team is updating data manually twice per day and since February 2020, the ArcGIS Living Atlas team from Esri is assisting JHU CSSE in a semi-automatic data flow strategy for updating dash [14].

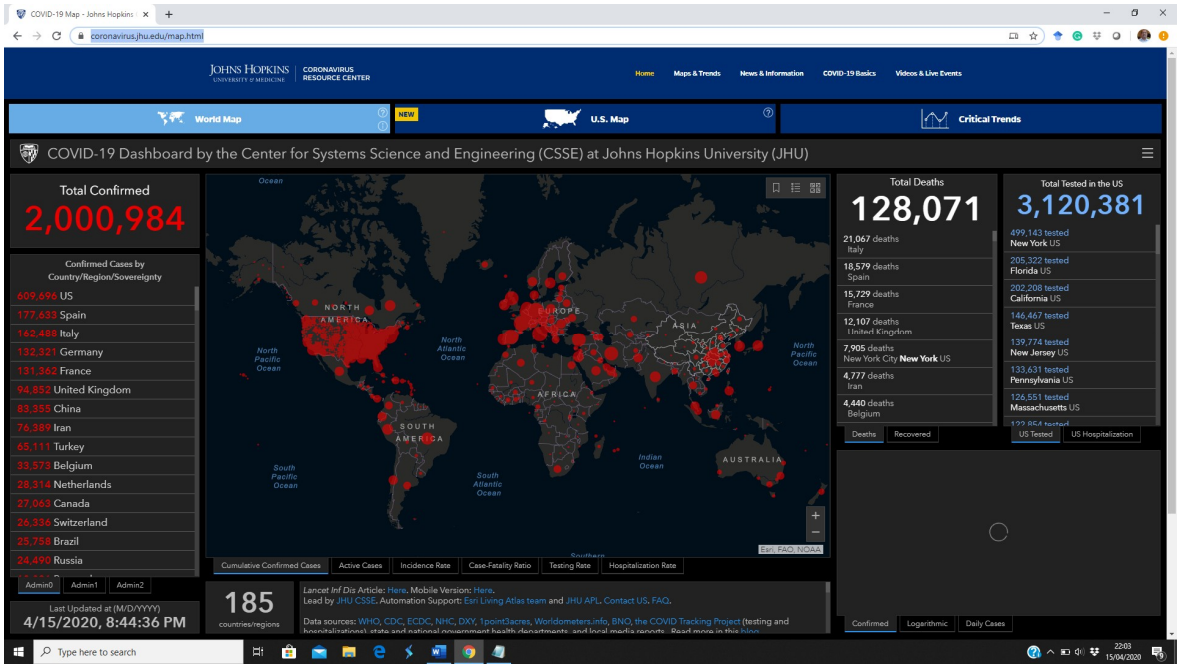


Figure 2. JHU CSSE is tracking the spread of COVID-19 dashboard that supported by relevant data from the WHO, US CDC and ECDC [16]

JHU CSSE Dashboard initially did not have an archiving service for the full map visualization of the previous day data and only has information in the form of a timeline graph of the total confirmed cases as well as the total recovered cases. But one is unable to retrieve and display detailed map snapshots in time [4]. Dashboard developers are supported to compile and create more interactive daily map snippets that can be accessed permanently as well as for future reference after the epidemic is gone, as a service to researchers and public health professionals around the world. The map display, for now, is more complete where various types of maps such as cumulative confirmed cases, the rate of events of active cases, case-fatality ratios, testing rates,

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and hospitalization rates. Case-fatality ratio (in percent) is calculated based on the number recorded deaths divided by number confirmed cases, US testing rate is based on total tested per 100,000 persons and US hospitalization rate (in percent) is calculated from the total number of hospitalized divided by number confirmed cases [16].

### 2.3. ESSC For COVID-19 Geoportal: Indonesia Context

The Emergency Spatial Support Center (ESSC) as an initiative of Esri Indonesia as a partner of the National Disaster Management Agency (BNPB) launched a geospatial system at the end of March 2020 using ArcGIS Enterprise to monitor the COVID-19 outbreak in Indonesia [17]. According to the Indonesian mainstream media [18], that the COVID-19 Geoportal is a health information tool that integrates information from relevant government agencies and visualizes it on the mapping dashboard. So that it can present the user with an actual picture of the outbreak when the case is revealed. The purpose of this system is: (1) Tacking the COVID-19 case in each province. This is using aggregation in transactional data and joining with spatial data, (2) Tracking activity of people under surveillance (ODP), patients in care (PDP) and positive cases based on manual survey or intelligence so the mayor could take an action seriously in the high-risk district. This is using hotspot spatial analysis based on survey records and (3) Gather all the data from COVID-19 partner hospitals so we could get the insight for deciding on distribution [17].

ESSC for COVID-19 Geoportal designed as a sharing media for Geographic Information System (GIS) contents related to the COVID-19 outbreak which occurs in Indonesia. Use the data and application on this Geoportal to monitor the COVID-19 update in real-time. ESSC For COVID-19 Geoportal system should handle many data sources, for example: (1) emergency phone call system, (2) manual excel/csv survey and intelligence file, (3) mobile survey and intelligence system, (4) patience record system and many more systems. In general, ESSC For COVID-19 Geoportal Big Data system will process (1) Excel/CSV: From manual report data, (2) Unstructured data: from social media with a specific hashtag, description field from emergency phone call system and (3) SOAP/REST: from many systems that will integrate to our system in ministry or partner and many format and schema.

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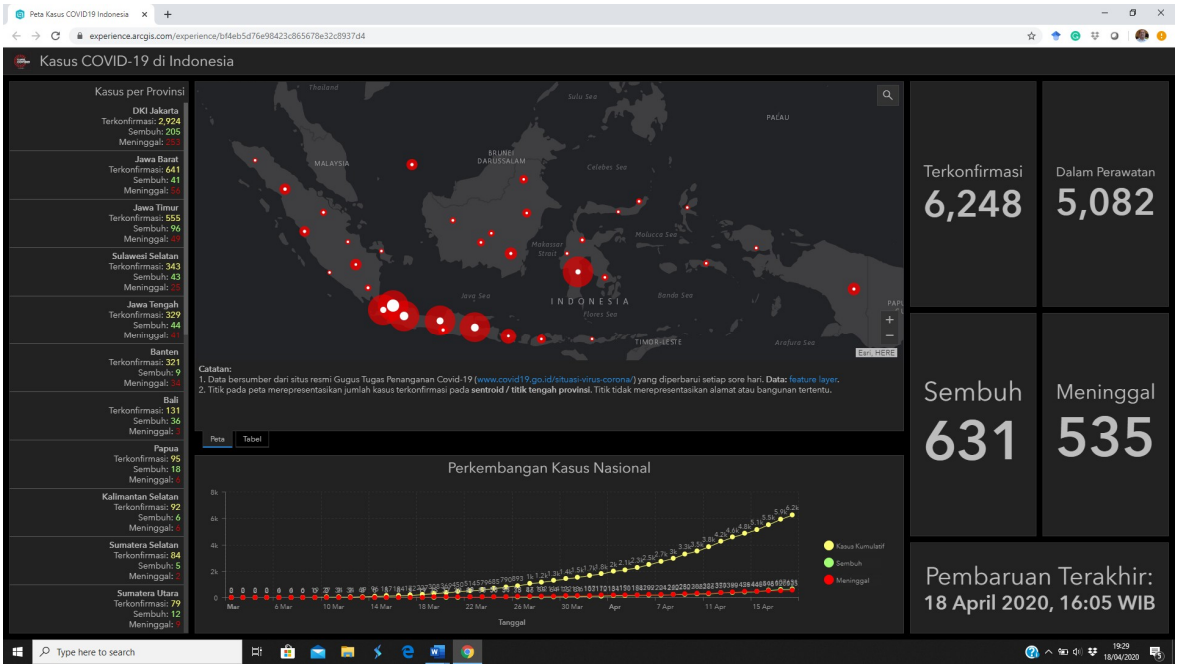


Figure 3. Emergency Spatial Support Center (ESSC) For COVID-19 Geoportal using ArcGIS GeoEvent Server as Ingestion software that supported by relevant data from the various national institution. Screen capture on March 18th, 2020 [17]

ESSC For COVID-19 Geoportal use ArcGIS GeoEvent Server as Ingestion software. ArcGIS GeoEvent Server, is a technology that enables real event-based data streams to be integrated as a GIS-based enterprise data source. Data allows to be shared, placed, and sent to multiple destinations, and allows users to connect to almost any type of streaming data. This technology can also automatically provide information when certain conditions occur which are entirely in real time [19]. GeoEvent could identification who could be inserting data into Big Data so there are an authentication and authorization system. In the identification step, the developer can identify who inserting our data and data source schema. In the filtration step, GeoEvent should filter what is a mandatory field that supports analysis data. If data is bad or broken, It would be dropped. In the validation step, the data will validate before we transform from source to target. In the transform step, the developer can transform data sources to target platform this will be mapping field per field between source to target. At the end in the integration step, the data would be store in multiple target platforms. First is HDFS as the system Data Warehouse. HDFS stored in Json and GeoJson format. Also, the target data mart/RDBMS system, if there is some system wants to consume the data via an RDBMS data connector.

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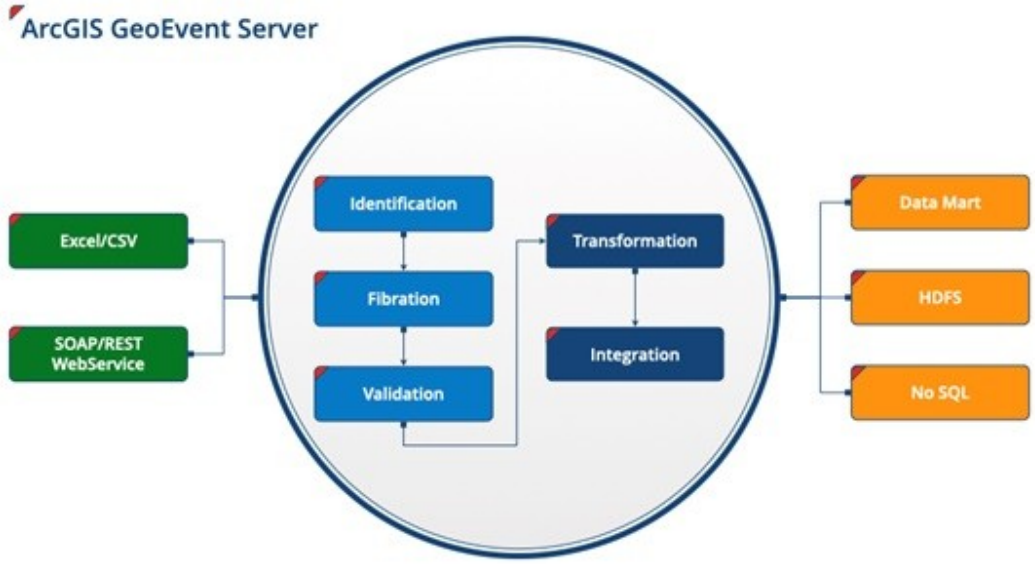


Figure 4. Ingestion Layer in ESSC for COVID-19 Geoportal Big Data System

The system also targeted the NoSQL database using MongoDB. This NoSQL database is using for showing the data into ArcGIS Enterprise and become Map Service. MongoDB will handle survey data so the data would display immediately. For NoSQL Technology, the system using two technology, CouchDB that is a bundle with ArcGIS Spatiotemporal Big Data store [19] and MongoDB. The System chooses MongoDB because Esri technology can load data from MongoDB via GeoJson format. The report data could store into MongoDB using GeoJson format and ArcGIS Enterprise could read it seamlessly because ArcGIS has data adapter with MongoDB so we could read it without writing a script anymore [20].

## 3. Discussion and Evaluation

The assessment of the GIS dashboard in this paper is based on a number of dashboards listed on the Center for Infectious Disease Research and Policy-CIDRAP website (https://www.cidrap.umn.edu/covid-19/maps-visuals) [21]. The two selected dashboards are based on the assessment of the performance especially the daily pageview and daily visitors using the StatShow website from IBM [13]. WHO COVID-19 dashboard being the first choice because it has daily pageviews around 5,276,390 and daily visitors up to 1,256,283. JHU CSSE dashboard

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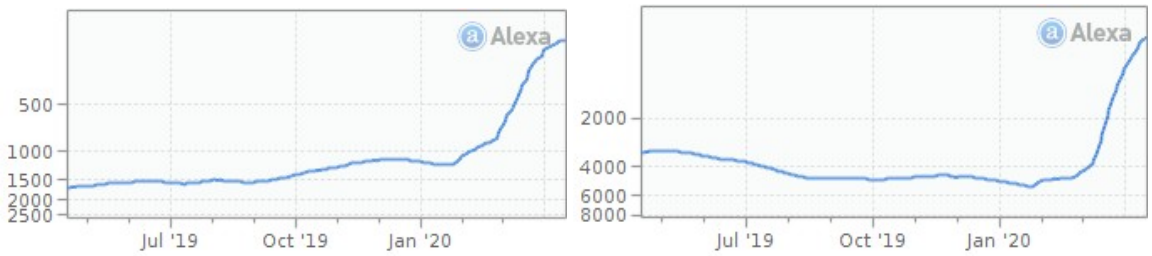
for the second choice with daily pageviews: 666,669 daily visitors up to 416,668. The two dashboards that were reviewed showed a dramatic jump in traffic since March 2020 (Fig.5)




a. Traffic Rank of covid19.who.int b. Traffic Rank of coronavirus.jhu.edu

Figure.5. the dramatic jump in traffic between WHO Coronavirus COVID-19 and JHU CSSE dashboards since March 2020 [13]

At this time the Dashboard from WHO looks almost similar to the JHU CSSE dashboard, mainly because it is based on official WHO data, so in fact the numbers on the JHU CSSE dashboard are updated later than the WHO dashboard. in addition to that there is no country level chart display showing data over time. The pros of this dashboard is that it uses official data from WHO [22]. According to [23] The process of reporting data from the national level to the WHO dashboard is recommended to use case-based or aggregate reports in which the determination of the form of the report is based on the capacity of the Health authorities and the number of cases in each country. The data streams are sourced from national authorities which are sent to regional contacts and then sent to WHO headquarters. The information reported by the national authorities is primarily on confirmed cases of COVID-19 infection within 48 hours of identification.

Since April 14$^{th}$ 2020, with the support of a non-profit technology company using WHO technology for COVID-19, an update on the substance of the dashboard content has been released which includes the daily and cumulative numbers for each new case as well as the number of deaths at the national level. This method allows information in the form of interactive maps and statistical information to view changes in time series in a country or region. The new WHO dashboard display is also designed so that users can easily access information where the variable to be selected can be selected using 3-dimensional data and is responsive so that it is convenient for users to access from mobile devices. The developer, in this case the WHO technology team, plans to update the data at both the national and provincial levels [24][25]

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Inspired by the dashboard that was created to deal with the measles outbreak in the US, the JHU CSSE dashboard to date is one of the most comprehensive dashboards built to disseminate COVID-19 case information globally using data updated faster than the WHO daily situation report. This made it possible because the JHU team collected data directly from WHO and national health authorities. The data on the WHO dashboard are sent in stages so that there is a time delay to be displayed immediately. JHU CSSE dashboard data is updated several times a day and the data is stored in the GitHub repository so that it can be accessed and used by the public [22]. This dashboard inspires many other dashboards around the world in terms of design and information display including the dashboard developed by ESSC COVID-19 Geoportal for Indonesia. According to [26], the dashboard has been revised three times, and the previous iteration used a poorly sized circle to describe the level of outbreak in a location. The text is small, and there is no way to learn more about specific cases or the history of the virus in certain locations. Apart from that is that the dashboard uses the color of gloom-and-doom, and Just one time series chart to view global cases over time with no country wise comparison over time [22] and rather clunky to navigate, it cannot be denied that the dashboard has advantages in offering a global look at this disease, near real time updates, the mobile version dashboard.

On April 13, 2020, JHU launched its new, US -Specific COVID-19 Tracking Map to complement JHU'S Global COVID-19. The dashboard complement will become a new comprehensive resource to view critical public health data in one place. The goal is to make these data as publicly and widely available as possible to help inform reporting and ongoing conversations and decision making about the COVID-19 [27]. The Dashboard layer is created and maintained by the CSSE at JHU and the feature layer is supported by the Esri Living Atlas team and JHU Data Services. Due to limitations in the data collection and reporting process, this new layer specifically for US only contains COVID-19 cases and the number of confirmed deaths. Although on the dashboard there is an option to display active and restored layer information, the data is not updated and can be ignored for the US only. The "Combined Key" field provides the name of the district, state, and country [28].

As JHU CSSE dashboard, the design and appearance of ESSC For COVID-19 Geoportal Indonesia are relatively the same as using scary red colors on a gloomy black background, this is based on the template that I have available on the Esri platform. The difference at the same time is an

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advantage is the use of ArcGIS GeoEvent Server as Ingestion software enables real-time event-based data streams to be integrated as data sources in the enterprise GIS. This server is also used on the WHO COVID-19 dashboard and there is no explanation whether it is also used in the JHU CSSE dashboard. ESSC For COVID-19 system of using public cloud-based deployment to host ESSC For COVID-19 Geoportal Big Data system for several reasons: (1) should setup our system immediately. With the cloud-based, setup of the Big Data system just in a day. The system can focus on content and strategy to fight COVID-19 pandemic, not for hardware infrastructure, (2) It easy to scale up. If current resource couldn't handle our data growth and processing map reduce need more hardware, it's easy to scale up our system with cloud and (3) No hardware maintenance. But nothing is perfect and Cloud Computing is no exception, using a public cloud for ESSC For COVID-19 Geoportal data for consideration, i.e. (1) Data Confidential. Store confidential data into system like survey data. At first time, the team think cloud its worst decision to host Big Data system to cloud because confidential. In the end, the system implements a hybrid cloud as the main system in the cloud but the data is always synchronized with the Indonesian National Data Center (INDC) and (2) Security. Concern about system security in the public cloud. So now implement an active directory to secure the system. Communication between machines, secure with SSL/TLS communication using domain certificates

## 4. Conclusion

In the international context, both WHO COVID-19 and JHU CSSE Dashboard have provided information for COVID-19 cases adequately in terms of information regarding the number and spread of cases around the world as expected by information users as they increase in user visits on the two dashboards significantly in the last two months. Although the two leading dashboards that inform COVID-19 cases around the world, they are inseparable from the shortcomings that the developers continue to improve upon and provide the necessary information. Since April 13, 2020, Johns Hopkins more focus on the US -Specific COVID-19 tracking map to complement JHU'S Global COVID-19 and include a new comprehensive resource for purposes of public health data. In the Indonesian context, ESSC For COVID-19 Geoportal has been developed in full dedication with the data and information from various parties and developed with the principles of big data management which is fully supported by adequate spatial portal developer software from

Esri. Especially in Indonesia, the availability of data and information from the authorities for all local authorities and the community is very important in planning preventive actions to prevent the transmission of viruses locally. the availability of adequate systems to support spatial-based decision making at the local level, it is strongly recommended that the development of the GIS dashboard support provincial and district governments.

## References

[1] Malik, Y. S., Sircar, S., Bhat, S., Sharun, K., Dhama, K., Dadar, M., ... & Chaicumpa, W. (2020). Emerging novel coronavirus (2019-nCoV)—current scenario, evolutionary perspective based on genome analysis and recent developments. *Veterinary Quarterly*, *40*(1), 68-76.

[2] World Health Organization-WHO (2020). Novel Coronavirus (2019-nCoV) SITUATION REPORT–1.https://www.who.int/docs/default-source/coronaviruse/situation-reports/20200121-sitrep-1-2019-ncov.pdf?sfvrsn=20a99c10_4. Accessed 10 Apr 2020

[3] World health Organization-WHO (2020) Rolling updates on coronavirus disease (COVID-19) update 9 April 2020. https://www.who.int/emergencies/diseases/novel-coronavirus-2019/events-as-they-happen. Accessed 1 Apr 2020

[4] Boulos, M. N. K., & Geraghty, E. M. (2020). Geographical tracking and mapping of coronavirus disease COVID-19/severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) epidemic and associated events around the world: how 21st century GIS technologies are supporting the global fight against outbreaks and epidemics. Int, J Health Geographic 19(8) 1-12

[5] Johns Hopkins. CSSE Coronavirus COVID-19 (2020). Global Cases (dashboard). https://coronavirus.jhu.edu/map.html. Accessed 10 Apr 2020

[6] Djalante, R., Lassa, J., Setiamarga, D., Mahfud, C., Sudjatma, A., Indrawan, M., ... & Gunawan, L. A. (2020). Review and analysis of current responses to COVID-19 in Indonesia: Period of January to March 2020. *Progress in Disaster Science*, 100091.

[7] Government of Indonesia (GoI). Situasi Virus Korona. Gugus Tugas Percepatan Penangnan COVID-19. https://www.covid19.go.id/situasi-virus-corona/. Update 13 Apr 2020

[8] Lyseen, A. K., Nøhr, C., Sørensen, E. M., Gudes, O., Geraghty, E. M., Shaw, N. T., ... & IMIA Health GIS Working Group. (2014). A review and framework for categorizing current research and development in health related geographical information systems (GIS) studies. *Yearbook of medical informatics*, *23*(01), 110-124

[9] Zhou, C., Su, F., Pei, T., Zhang, A., Du, Y., Luo, B., ... & Song, C. (2020). COVID-19: challenges to GIS with big data. *Geography and Sustainability* (in press)

[10] Esri China (Hong Kong).(2020). List of Novel Coronavirus Dashboard. https://story maps.arcgi s.com/stori es/a1746 ada9b ff48c 09ef7 6e5a7 88b59 10 and https ://go.esri.com/coron aviru s. Accessed 13 Apr 2020.

[11] World Health Organization (2020).about WHO. https://www.who.int/ . Accessed 5 Apr 2020.

[12] World Health Organization (2020). Novel coronavirus (COVID-19) situation (public dashboard). https://covid19.who.int/. Accessed 1 Apr 2020

[13[ Statshow, 2020. StatShow the stats maker. https://www.statshow.com/. Accessed 10 Apr 2020

[14] Gardner L.(2020). Mapping 2019-nCoV (23 January 2020). https ://syste ms.jhu.edu/resea rch/publi c-healt h/ncov/. Updated 11 Feb 2020

[15] Dong, E., Du, H., & Gardner, L. (2020). An interactive web-based dashboard to track COVID-19 in real time. *The Lancet infectious diseases*. doi.org/10.1016/S1473-3099(20)30120-1

[16] Johns Hopkins. CSSE Coronavirus COVID-19 (2020). Global Cases (dashboard). https ://gisan ddata .maps.arcgi s.com/apps/opsda shboa rd/index .html#/ bda75 94740 fd402 99423 467b4 8e9ec f6. Accessed 6 Apr 2020

[17] Esri Indonesia.(2020). ESSC For COVID-19 Geoportal. https://essc-kawalcovid19.hub.arcgis.com/. Accessed 8 Apr 2020

[18] Kompas. (2020). Bantu Pemerintah Pantau Penyebaran Corona, Esri Indonesia Luncurkan Geoportal COVID-19. https://money.kompas.com/read/2020/03/31/191522326/bantu-pemerintah-pantau-penyebaran-corona-esri-indonesia-luncurkan-geoportal. Accessed 8 Apr 2020

[19] Esri.(2019). GeoEvent Server. Managing spatiotemporal big data stores. https://enterprise.arcgis.com/en/geoevent/latest/administer/managing-big-data-stores.htm. Accessed 8 Apr 2020

[20] Huang, B. (2017). *Comprehensive geographic information systems*. Elsevier.

[21] Center for Infection Disease Research and Policy- CIDRAP University of Minnesota. (2020). COVID-19 Maps & Visuals. https://www.cidrap.umn.edu/covid-19/maps-visuals. Accessed 8 Apr 2020

[22] Zubair. M. (2020). Best Dashboard to Track Coronavirus-List of Regional & Top 5 Global Dasboard to Follow. https://towardsdatascience.com/best-dashboards-to-track-coronavirus-7ac4b8b79445. Accessed 10 Apr 2020

[23] World Health Organization (2020). Global surveillance for COVID-19 caused by human infection with COVID-19 virus-Interim guidance (20 March 2020), https://www.who.int/publications-detail/global-surveillance-for-human-infection-with-novel-coronavirus-(2019-ncov). Accessed 10 Apr 2020

[24] World Health Organization (2020). Rolling update on coronavirus disease (COVID-19)-Major update to COVID-19 dashboard. https://www.who.int/emergencies/diseases/novel-coronavirus-2019/events-as-they-happen. Accessed 24 Apr 2020

[25] World Health Organization (2020). WHO updates COVID-19 dashboard with better data visualization. https://www.who.int/news-room/feature-stories/detail/who-updates-covid-19-dashboard-with-better-data-visualization. Accessed 24 Apr 2020

[26] Patel. N.V. (2020). The best, and the worst, of the coronavirus dashboards. MIT Technology Review. https://www.technologyreview.com/2020/03/06/905436/best-worst-coronavirus-dashboards/. Accessed 24 Apr 2020

[27] Johns Hopkins University-JHU (23 March 2020). ADVISORY: Johns Hopkins University Upgrades COVID-19 Tracking Map With Local U.S. Data (News Releases). https://releases.jhu.edu/2020/03/23/advisory-johns-hopkins-university-upgrades-covid-19-tracking-map-with-local-u-s-data/. Accessed 10 Apr 2020

[28] Harries, J. (2020). COVID-19 Data Available by County from Johns Hopkins University. https://www.esri.com/arcgis-blog/products/product/public-safety/coronavirus-covid-19-data-available-by-county-from-johns-hopkins-university/. Accessed 10 Apr 2020