Map Design Effectiveness of COVID-19 Disease Using ArcGIS Pro and Adobe Creative Cloud: An Exploratory Study from an Educational Perspective in Malaysia

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Abstract. Disease mapping is a visual representation of a disease's geographical distribution within a population that is used to determine the origin of an outbreak. Designing an ideal disease map provides useful information to understand the current situation of COVID-19 and supports decision-making in Malaysia. The current map may fall short of meeting the necessary criteria for a cartographic map, and it primarily relies on commercial software. This study designed a cartographic disease map of COVID-19 in Selangor by exploring the latest 2.0 version of ArcGIS Pro and Adobe Creative Cloud. This exploratory study utilised the ESRI cloud platform to create a COVID-19 disease map that adhered to a good cartography map design and element as conducted at the university. This allowed the researchers to gain first-hand experience with the practical capabilities of both commercial and cloud platforms. Then, the map's effectiveness was evaluated based on the user's experience and expert opinion. The combination of ArcGIS Pro and Adobe Creative Cloud is effective for producing detailed and aesthetically pleasing maps. Cloud platforms offer cost-efficiency, accessibility, collaboration, scalability, and automatic updates for map design, enabling users to generate accurate maps of various data types, enhance visual appeal, and improve data communication for effective disease tracking of the COVID-19.

Keywords: Cartography, COVID-19, Disease Mapping, GIS Cloud Software, Map Design Effectiveness.

1   Introduction

The Ministry of Health (MOH) in Malaysia recorded 5,251 COVID-19 cases as of April 17, 2020, with 86 fatalities and 2,967 instances of recovery [1]. To date, Selangor in Malaysia has experienced the largest number of confirmed COVID-19 cases (1,338) on 17 April 2020. Because of the huge number of positive cases identified in certain locations, the government designated 27 districts as red zones, including Lembah Pantai (592), Hulu Langat (446), Petaling Jaya (366), Seremban (288), Kuching (255), and

Kluang (221) (MHO, 2020). GIS mapping is decisively needed for visualising infection spread, identifying hotspots, optimizing resource allocation, and guiding public health interventions.

Therefore, people worldwide may access geoinformation via map-based dashboards, allowing them to safeguard themselves and their communities. This sort of solution enhances data transparency and aids in the dissemination of information by authorities [2]. Mapping the COVID-19 disease can be the most valuable, and data visualizations from the COVID-19 epidemic have helped us understand, respond, and recover. Other than that, several maps use a range of digital tools to assess the likely spread of COVID-19, while others follow the pandemic's socioeconomic effect. Even a new data-driven tool is being developed to aid municipal governments and health practitioners, particularly in low- and middle-income settings, in planning and managing future infectious disease epidemics [3].

When constructing the COVID-19 disease map, utilize various mechanisms to create and analyse the provided material in a distributed, real-time manner. The usefulness of using statistical models and mapping tools in developing health policy has been proven by experience with disease outbreaks. Despite ongoing advancements in disease mapping technology, a persistent issue remains the heterogeneity of disease data. Different health institutions acquire disease data in different ways, which provides a barrier to data exchange. These data may be saved and delivered in a variety of locations using files or databases. Another challenge is ensuring appropriate cartographical representation and sensitive dissemination of disease data. Cartographical representation is one way to deal with data representation in graphics.

To deliver information regarding the pandemic, the Ministry of Health Malaysia (KKM) established a committee to create a disease map about the COVID-19 pandemic using GIS mapping techniques. Uses of GIS are necessary, as their effectiveness in analysing the disease will be determined by their data sources and resolution, as well as the information that supports them. While the KKM's map is a significant step in disseminating information to civilians, it falls short of meeting the standards of a cartographic map. This study focuses on using cartographic elements and map design [4] to create an effective disease map for COVID-19 with ArcGIS Pro and Adobe Create Cloud. Adobe Creative Cloud, which now has a direct link to Esri's desktop application, ArcGIS Pro, can better represent and provide more information about COVID-19. The study also evaluates the map's effectiveness in showing an ideal disease map using this cloud platform. Cloud computing is rarely used in Malaysia; therefore, this study can also investigate the software's capability to create an effective disease map in the country.

2   Literature Review

On January 30, 2020, the WHO designated the COVID-19 outbreak a public health emergency of worldwide concern [5]. The WHO's main fear was that the virus might move to nations with weaker health systems, leaving them unable to deal with an outbreak. According to modelling research published in The Lancet on January 31,

every infected person infects 2.68 more people on average. The exact mechanism through which the virus spreads from person to person is also unknown. On January 25, 2020, the first three cases of COVID-19 in Malaysia were verified to be imported cases. Imported cases are infections acquired outside of Malaysia, as determined by the particular case's travel history. GIS mapping is crucial for visualising infection spread, identifying hotspots, optimising resource allocation, and guiding public health interventions.

As you already know, a basic overview of the illness status in a certain geographic area is provided by disease mapping, which uses disease maps as visual representations of complex geographic data. Epidemiology is focused on investigating illness causes, which frequently vary in frequency and spatial distribution [6]. Numerous COVID-19 disease maps have been published publicly by KKM or even other agencies. However, some of the maps do not adhere to the design principles of cartography as suggested by [4]. Most of the maps lack a legend relating to the desired information; in addition, a lack of cartography principles often results in a map that is not easily readable and understood by the viewer. The next step is to create a well-balanced map page that ensures an impression of equilibrium and harmony. As the map below demonstrates, it is somewhat unbalanced. Reference [4] gave tips for conducting the best practices map design including effective mapping, cartography and design principles and map evaluation,

Desktop-based or commercial GIS software was widely used for environmental activities such as land use and utility mapping, ecological modelling, landscape evaluation, transportation planning and infrastructure development, market analysis, visual impact analysis, and a variety of other services [7-11]. GIS software is widely used in a variety of applications around the world. This geospatial-based platform has been also used in Malaysia for vector disease, waterborne and foodborne illness, airborne disease, non-communicable disease research, and industrial applications [12-15]. Although commercial or proprietary software (such as ArcGIS) offers technological advantages in complex analytic methodologies, cost and technical limitations should be considered in local health sector implementation, particularly for low-income nationwide applications and sustainable practices. Therefore, cloud-based software is an alternative that is a more cost-effective, accessible, and flexible solution than traditional desktop software [16].

GIS and cartographic methods for disease mapping provide accurate visualisation, reveal spatial patterns, support targeted interventions, enhance resource allocation, improve monitoring, and facilitate informed public health decision-making and policy development [17]. However, current disease mapping lacks accuracy, misses spatial patterns, hampers targeted interventions, and leads to inefficient resource allocation and decision-making. Ideal disease mapping shall rely on the right cartographic techniques for accurate visualisation, pattern detection, informed interventions, and effective resource allocation. GIS and carto-graphic methods for COVID-19 mapping provide precise visualisation, track spread, identify hotspots, support targeted interventions, optimise resource distribution, enhance monitoring, and inform public health policies and responses [18].

As the user base for disease maps grows, it's important to prioritise several crucial characteristics that enhance their application in the field of public health. According to reference [19], five crucial characteristics of disease maps will make them suitable for public health applications. These characteristics include controlling the population to provide spatial support for rate estimates, continuously displaying rates through space, providing maximum geographic detail across the map, taking into account both directly and indirectly age-sex-adjusted rates, and visualising rates within a relevant place context to enhance interpretation.

ArcGIS Online is a cloud-based mapping tool for companies that can be used anywhere in the context of health applications on a smartphone, web browser, or desktop application. ArcGIS Maps for Adobe Creative Cloud, a component of the Esri Geospatial Cloud, enables creative professionals to view and work with da-ta-driven maps inside Adobe Illustrator and Photoshop [20]. Users can simply design and efficiently visualise the disease map by pulling in geographical data from Adobe Photoshop and Illustrator without even having to leave the application, and free, unlimited access to public maps and layers hosted in ArcGIS Online is provided to all users on a single computer. It is also no longer necessary to trace maps to highlight certain locations of interest.

3   Methodology

The study workflow was divided into five (5) phases of research: a preliminary study, data collection, data processing, data analysis and mapping, and outcomes (Fig. 1), to meet the aims and objectives of the study. The main guideline of the map design of the study is based on reference [4], covering effective maps, cartography principles and map evaluation. Preliminary studies cover site selection, study software selection, and site preparation, including surveying equipment and instruments. This study mainly focuses on Selangor, which consists of Gombak, Hulu Langat, Hulu Selangor, Klang, Kuala Langat, Kuala Selangor, Petaling, Sabak Bernam, and Sepang. In 2020, the estimated population of Selangor civilians was 6,518,500, and Selangor's total area was 8,104 km^2. The state has also recorded the highest number of COVID-19 cases in Malaysia.

The study's main data collection includes secondary data from survey questionnaires and interviews. Secondary data on COVID-19 cases were collected from KKM. The data processing phase was conducted to create a COVID-19 disease map using the ESRI capabilities of ArcGIS Pro with Adobe Creative Cloud. This combination of cloud platforms allows for a comprehensive and creative approach to mapping and analysing COVID-19 data. To calculate the COVID-19 case rate types, we divided the total number of recoveries by the total number of verified cases. The ratio of active cases to confirmed cases is known as the active case rate. It is calculated by deducting the total number of confirmed cases from the total number of recoveries and fatalities. We cross-check the capabilities of ArcGIS Pro and Adobe Creative Cloud with users, including those on the platform, the public, and selected experts who have evaluated and rated these tools for creating an ideal COVID-19 disease. The selected experts

evaluated the software's capabilities based on their experience using it and the product's outcome. The users who are trying to grasp the value of ArcGIS Pro in comparison to Adobe Creative Cloud found the criteria table to be a very helpful reference (Table 1).

Table 1. Proposed criteria for effective map design

Capabilities	Criteria Scale				
	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Design simply and efficiently					
Seamless experience					
Organize layers					

4   Result and Discussion

4.1   Exploring ArcGIS Pro and Adobe Creative Cloud Capabilities in Mapping COVID-19 Disease

The cloud platform capabilities in creating COVID-19 map designs were reviewed by certain criteria, as shown in Table 1. With ArcGIS Pro and Adobe Creative Cloud, users can easily and quickly create maps of diseases for simple and efficient design. The users can also produce visually appealing and aesthetically captivating maps that appropriately depict epidemiological data. In addition, this cloud provides a seamless experience when creating a disease map. Creative Cloud provides potent tools for graphic design, video editing, and general digital asset management. In terms of the organised layer, the process of producing a disease map begins with an essential stage that involves organising different layers using the cloud. ArcGIS Pro gives users the flexibility to change the symbology, reorder the layers, and set the drawing order. Users can ensure that the information is shown accurately and clearly by investing the effort required to organise the map's layers in the appropriate order.

The elements for a good cartography map design are also considered in the mapping of the disease. When making their maps and putting together page layouts, cartographers draw inspiration from a wide variety of design sources. Five of the most important aspects of design are legibility, visual contrast, figure-ground relationships, hierarchical order, and balance. These components, when combined, provide a framework for determining and appreciating the relative significance of the information presented on the page and the map. They are essential to the operation of the map-based communication system. Together, readability and visual contrast provide the building blocks necessary to comprehend the various features depicted on the map. The reader

of the map is led through the various contents to evaluate the significance of the various components before discovering patterns through the utilisation of balance, figure-ground contrast, and hierarchical arrangement.

4.2   Harnessing COVID-19 Map Design with ArcGIS Pro and Adobe Creative Cloud

The combination of ArcGIS Pro with Adobe Creative Cloud makes it easier and more efficient than ever for users to produce detailed and beautiful maps. The users can produce visually appealing maps that can be used to illustrate many types of data, such as disease prevalence, population, or climate change, by combining the strengths of the two tools. Users can produce and view GIS data using ArcGIS Pro, a robust GIS software program created by Esri. Users may easily construct comprehensive maps containing layers of data, such as points, lines, and polygons, using the built-in tools.

ArcGIS Pro also provides a vast library of several features, including environment layers, satellite and aerial photography, and more. Adobe Creative Cloud, on the other hand, is a collection of artistic tools that enables users to produce graphics and designs at a professional level. Applications like Photoshop, Illustrator, and InDesign are part of the Creative Cloud, which enables users to combine text and images to produce intricate and beautiful graphics. Users can produce precise, aesthetically pleasing maps that accurately depict the data they are aiming to express when ArcGIS Pro and Adobe Creative Cloud are combined.

The comparative analysis, based on a good cartography map (B) view, can be interpreted as a comparison of visual hierarchy, scale, symbolization, typography, and lettering (Fig. 1) with the existing COVID-19 map (A). The term "visual hierarchy" refers to the apparent importance of items to the human eye. The background is made up of colours with a lower saturation level, while the foreground is made up of colours with a higher saturation level. With icons, the foreground can also be brought into focus.

The scale of the map was determined to be a happy medium between the number of features shown and the overall perspective it offered so that the geographical context could be understood clearly. While symbolization on the map that has been proposed is possible, it is possible to have the different types of cases correspond to the areas represented by symbols and to have the different numbers of deaths recorded per district correspond to the circles. In terms of typography and lettering, the proposed map employs more readable typography than the one currently in use. Text placement is another challenging process because it must be carried out consistently about both its size and its positioning.
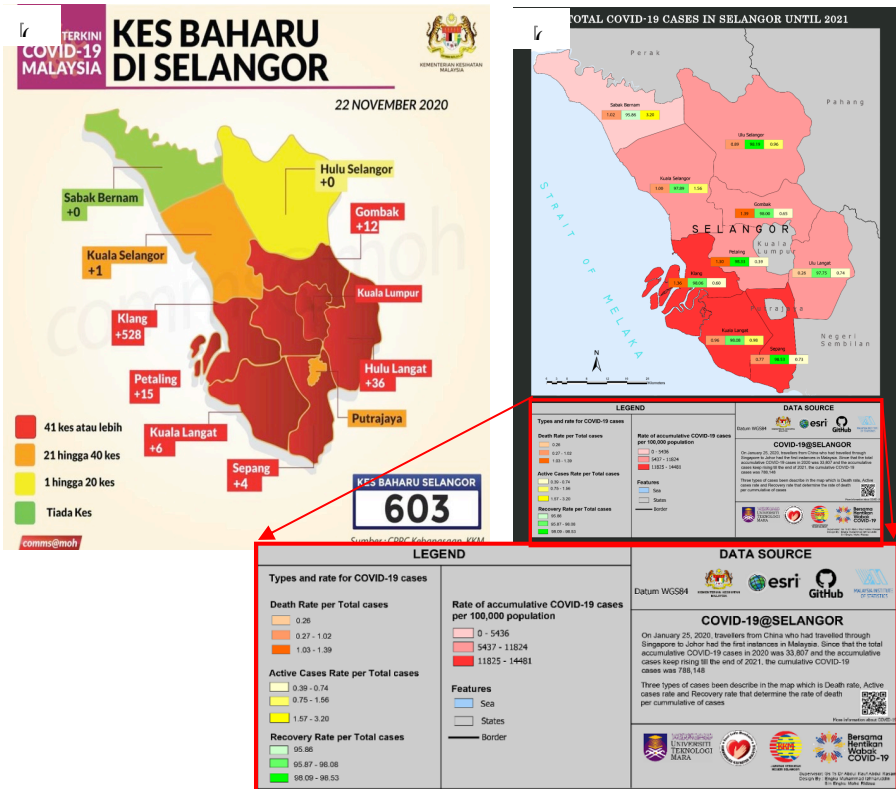
Fig. 1. The existing COVID-19 map and proposed COVID-19 map in Selangor

4.3 Evaluating the Map Effectiveness of the COVID-19 Disease Using ArcGIS Pro and Adobe Creative Cloud

This study tested the proposed COVID-19 map based on five user experiences and expert opinions, taking into account the capabilities of ArcGIS Pro and Adobe Creative Cloud, such as practical design, seamless experience, and layer organization processes. The user's experience was rated based on the capabilities on a five-Likert scale, as shown in Fig. 2. ArcGIS Pro and Adobe Creative Cloud offer an effective mapping and analytic solution in a dependable, cost-effective, and user-friendly environment. The users also agree with the ability of the platform to produce good symbols, colours, and scales, as well as reliable, beautiful, and up-to-date map design.

Rate the capabilities of ArcGIS Pro with Adobe Creative Cloud while making the COVID-19 map
5 responses
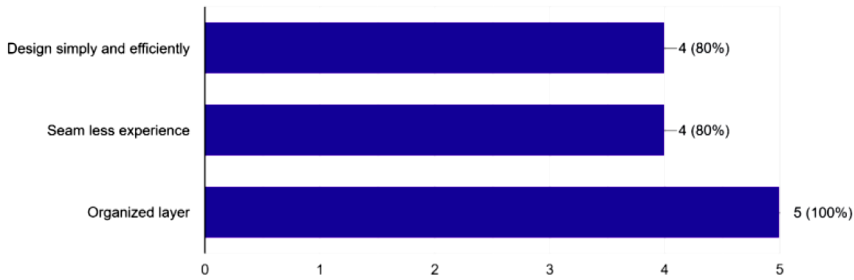
Fig. 2. Overall response from the selected users on the Cloud platform

The map's testing was also conducted via an online platform using a Google Form, with 22 respondents from the public. Although the majority (54.5%) has seen a similar map (an existing map) to the proposed map, several aspects of the map need improvement, especially poor map design and colour selection. Therefore, 84.2% of the respondents recommended that ArcGIS Pro and Adobe Creative Cloud could be applied to produce a better map version of the disease. Fig. 3 shows the map elements and criteria that the researchers should also consider when producing the proposed COVID-19 map in Selangor, as suggested by the respondents.
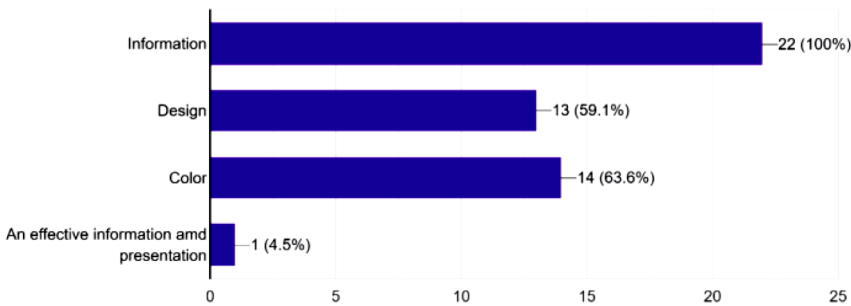
Fig. 3. The significant elements that are needed in the proposed COVID-19 map of Selangor

Based on the respondents' proposed criteria, the selected experts evaluated the proposed COVID-19 map based on certain practical capabilities. These criteria included: i. Enough information to make it a decent COVID-19 map; ii. Providing detailed information on the rate of COVID-19 cases; and iii. Creating a user-friendly map. iv. A well-designed map incorporates elements such as colour and visibility; v. The map can be integrated with digital, system, or app platforms with web multimedia aspects. The overall result, as indicated in Fig. 4, revealed that most of the respondents agreed

with the map elements and design recommended in the proposed COVID-19 map. For instance, the respondents concurred with the proposed map's information criteria and found it to be a user-friendly platform. They also suggested that the map should be integrated with multimedia digital, system, or app platforms for sharing intriguing geoinformation with the public.
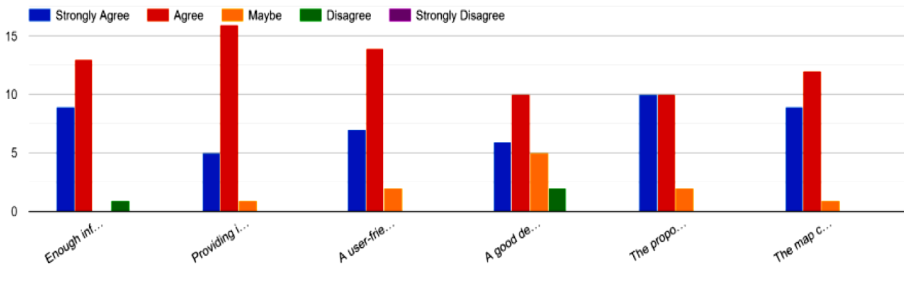

Fig. 4. Practical capabilities of the Proposed Map based on the following criteria

5   Conclusion

The GIS software and cartographic elements' capabilities significantly contributed to the creation of the ideal COVID-19 map in Selangor. The existing map still falls short of meeting the criteria for a cartography map and primarily relies on paid or commercial software. This study showcased the potential of a cloud platform to facilitate the creation of ideal cartographic disease maps. Based on ArcGIS Pro and Ado Based on the capabilities of ArcGIS Pro and Adobe Creative Cloud, as well as the criteria for a satisfactory map design, it has provided a proposed map of COVID-19 in the state, enabling map users to quickly and easily create. The map guides the reader through its various contents, allowing them to assess the significance of each component before identifying patterns within the proposed map. The combination of ArcGIS Pro and Adobe Creative Cloud is also effective for producing detailed and aesthetically pleasing maps. Users can quickly and simply generate maps using these tools that accurately depict several data types, including illness prevalence, population density, and types of cases. The selected evaluator agrees. The selected evaluators concurred that the proposed map contains sufficient information to serve as an effective COVID-19 map, offering detailed information on the rate of COVID-19 cases and boasting a user-friendly interface. Future studies suggest a cloud platform for COVID-19 mapping could offer precise visualisation, tracking, intervention support, resource distribution optimization, monitoring, and policy information.

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