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Normalizing the pandemic: exploring the cartographic issues in state government COVID-19 dashboards

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ABSTRACT

Government agencies have utilized Web Geographic Information Systems (GIS) dashboards to collect and disseminate spatial information on COVID-19. However, not all maps on these dashboards adhere to established cartographic principles. This article explores the extent of the cartographic issues by surveying state governments' official COVID-19 websites in the United States on February 11, 2021. The results indicate that out of the fifty states, thirty-one (62.0%) incorrectly used unnormalized data in choropleth maps, sixteen (32.0%) used normalized data, and three (6.0%) did not employ choropleth maps. Among states using normalized data correctly, we identified other cartographic problems, including inappropriate data class divisions and suboptimal enumeration units. As dashboards serve as authoritative sources for health information, issues in map creation can influence public perception of the health crisis. These findings underscore the need for map standards to ensure the accuracy and reliability of health information in the Web GIS era.

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1. Introduction

The coronavirus disease 2019 (COVID-19) pandemic has disrupted nearly every aspect of our society and is responsible for an unprecedented public health calamity in the United States (Centers for Disease Control and Prevention, 2021). Since the disease information is organized spatially, governments have employed geospatial information technology to monitor and respond to the virus spread in close to real-time (Kamel Boulos & Geraghty, 2020). With Web Geographic Information Systems (GIS) that automate map creation and distribution, public users and authorities can quickly develop, share, and update health information using web maps quickly enough to make actionable decisions (Richards, 1999; Zhang et al., 2015; Zhang & Li, 2005). One of the most widely used tools to host web maps is the dashboard, a hosted web service that facilitates interactive visualization of spatial and non-spatial data (Dong et al., 2020; Griffin, 2020). After the initialization of the COVID-19 dashboard by Johns Hopkins University (Dong et al., 2020), all fifty United States state governments created their own dashboards to enhance pandemic surveillance and facilitate health communication. Dashboards became the default method for communicating relevant information involving the pandemic with the general public, and each state made different design decisions (Geraghty & Artz, 2022).

Although the COVID-19 dashboard is considered 'the most striking cultural artifact' of the pandemic (Everts, 2020), considerable issues arise as they do not always follow cartographic principles (Adams et al., 2020). In this study, we observed that the dominant map type used in dashboards is the choropleth map, which is a thematic map type using the intensity of colors to correspond to data values within spatial enumeration units (Dent, 1990; Tobler, 1973). Choropleth maps are one of the most popular thematic map types, and some cartographic principles have been well established to ensure their proper use, such as data normalization and map symbology principles (Brewer & Pickle, 2002; Harrower & Brewer, 2003; Jenks, 1963; Jenks & Caspall, 1971). However, dashboard developers, including those employed by an authoritative agency, may not have the essential training to comply with these principles (Harrower & Brewer, 2003; Juergens, 2020; Lan et al., 2021; Plewe, 2007).

One prevailing cartographic issue in choropleth-based dashboards is the failure to use normalized data for mapping – that is, using a relative value (e.g. infection rates) rather than an absolute value (e.g. cases of infection) (Adams et al., 2020; Engel et al., 2022;

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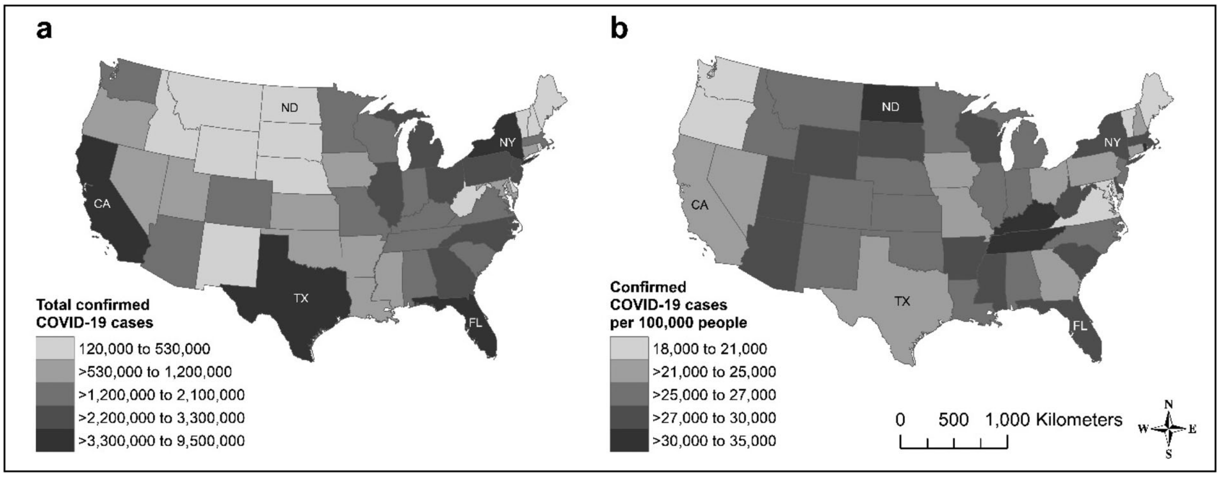

Figure 1. (a) Total infections by state and (b) infection rates in terms of cases per 100,000 people by state. Case data were derived from the CDC as of May 28, 2022. Class breaks were created using Jenks natural breaks in ArcMap, and labels are rounded to two significant digits for simplicity.

Kronenfelda & Yoo, 2020). Violating this principle may disguise spatial patterns due to comparing absolute values in different sizes of enumeration units (Dent, 1990; Krygier & Wood, 2005; Monmonier, 2018; Rezk & Hendawy, 2023). In the case of the COVID-19 pandemic, research has shown that choropleth maps that show only totals may change people's perception of the pandemic (Engel et al., 2022). Therefore, it is recommended not to use totals in a choropleth map (Adams et al., 2020). If totals need to be depicted, other map symbolizations, such as proportional symbols, area cartograms, or dot density, may be used (Brewer, 2016; Dent, 1990; Zhang, 2020). While it is possible to find examples in the literature where a choropleth map showing totals is appropriate, that same literature recommends considering graduated symbols in these cases (Krygier & Wood, 2005).

Figure 1, created from available data on the Centers for Disease Control and Prevention (CDC)'s COVID-19 website on May 28, 2022, demonstrates why this matters with two choropleth maps displaying the same case data (Centers for Disease Control and Prevention, 2022). Figure 1(a) shows the total cases of infection by state, and Figure 1(b) shows infection rates per 100,000 population. As shown in Figure 1(a), California, Florida, New York, and Texas, all have the most overall cases. There is no coincidence that these four states also have the largest population in the US, and Figure 1(a) reflects this pattern (Census Bureau, 2022). Figure 1(b) shows the infection rate per 100,000 people, which better facilitates comparisons among states with small and large populations. Thus, using an unnormalized map may mislead the public or decision-makers about the severity of the pandemic; for example, North Dakota's high infection rate is only unveiled in the normalized map (Figure 1(b)).

While this cartographic bias has been documented in the literature, it has not been well recognized by most public health professionals and map readers. For example, while the CDC has switched to publishing normalized case data, it still uses choropleth maps to show total cases well into the COVID-19 pandemic (Centers for Disease Control and Prevention, 2021, 2022). While other reviews of dashboards have looked at the issue and others, including visualizations besides maps and the frequency of updates (Clarkson, 2023; Fareed et al., 2021; Kronenfelda & Yoo, 2020), they may not contain data for the entire duration of the pandemic due to the dynamic nature of web maps.

To this end, this paper aims to articulate the cartographic issues in the COVID-19 dashboards published by all fifty state governments in the United States. Specifically, on February 11, 2021, we examined whether state governments employed a choropleth map or another map form for publishing COVID-19 case data. Then, we identified if these official web maps followed fundamental cartographic principles, including data normalization, number of classes, color schemes, and enumeration unit selection. On April 8, 2023, following the United States Senate vote to end the pandemic, we returned to each Uniform Resource Locator (URL) to determine the number of states still hosted the COVID-19 dashboards. This review can serve as a partial record of how the state governments of the United States portrayed spatial data during the COVID-19 pandemic for future researchers. Eventually, we hope efforts can be made to improve the consistency and accuracy of health information delivery.

2. Methods and results

To evaluate the extent of the cartographic issues in COVID-19 maps, we identified all fifty states' official websites where case data were published in terms of a dashboard or other types of web maps (Table 2). We excluded Puerto Rico, Guam, Washington D.C.,

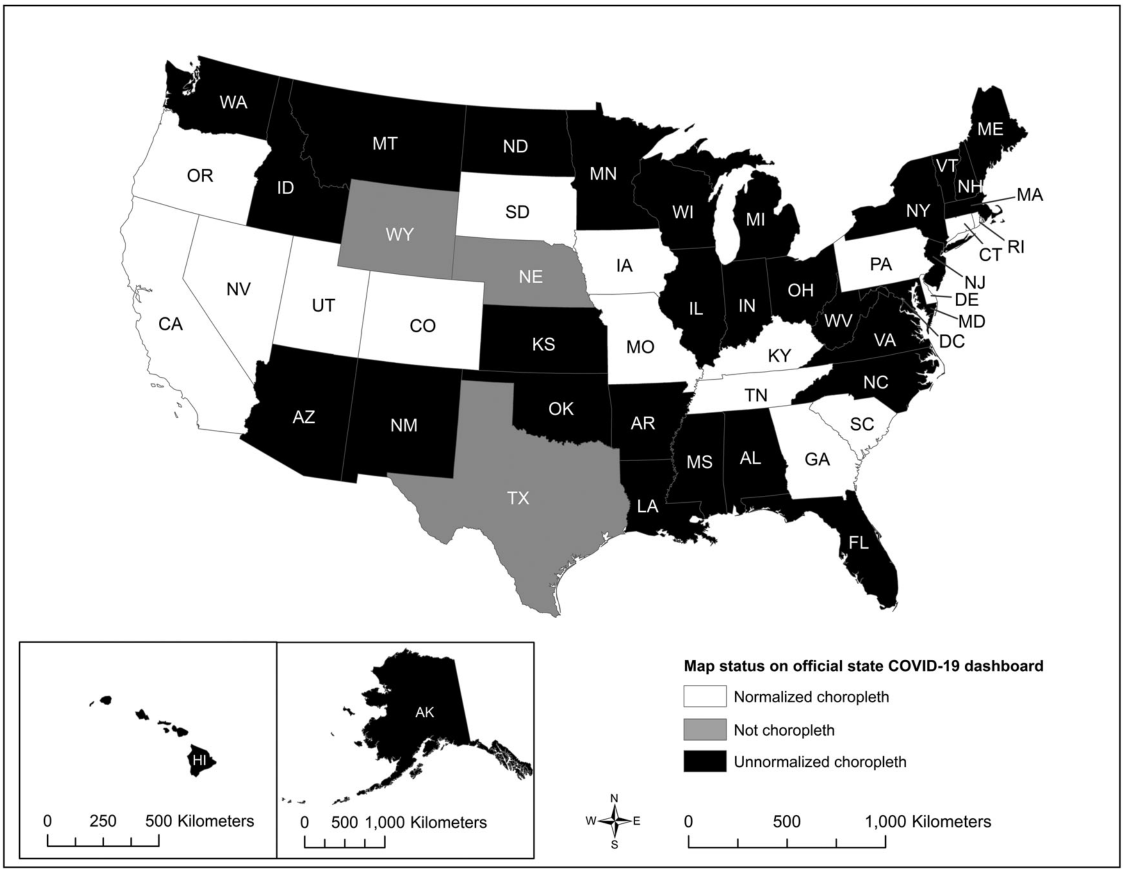

Figure 2. Data normalization status on state COVID-19 dashboards by state.

and other parts of the United States not within state boundaries to limit the study to comparable administrative units. We then recorded the types of thematic maps used on the websites, mainly choropleth maps and proportional symbol maps (i.e. maps using different sizes of circles). If a choropleth map was used, we checked if the cartographers employed normalized data (e.g. infection rates) or inappropriately used unnormalized data (e.g. total cases). We recorded dashboard URLs along with the data collection, which took place on February 11, 2021.

As Table 1 illustrates, all states employed certain forms of COVID-19 dashboards to visualize case data. Forty-seven states (94.0%) used choropleth maps, while two states (4.0%), Texas and Wyoming, used proportional symbol maps. The state of Nebraska had a general reference map but lacked any form of thematic map related to COVID-19 cases, with its website indicating that a map was under production. Colorado was the only state employing both choropleth and proportional symbol maps.

Figure 2 visualizes the findings by state. We found that thirty-one states (62.0%) used unnormalized data in their choropleth maps in at least one map on their dashboard, sixteen states (32.0%) rigorously stuck to normalized data in their choropleth maps, and three states (6.0%) did not employ choropleth maps. We observed that at least eleven states, including Alaska, Alabama, Arizona, Hawaii, Indiana, Michigan, Mississippi, North Carolina, North Dakota, West Virginia, and Wisconsin, employed choropleth maps showing both normalized and unnormalized cases, which we recorded as using unnormalized choropleth maps. We also found that the CDC had both normalized and unnormalized data on its web maps (Centers for Disease Control and Prevention, 2021). We acknowledge that as dashboards often have multiple visualizations, we may have missed a map that was either normalized or unnormalized. Such an omission would increase the number of states using both but not decrease the scale of the normalization issue. These findings demonstrate that the problem of misusing choropleth maps to visualize total COVID-19 cases was widespread.

To investigate further, we separately evaluated the three categories of normalized choropleth, not choropleth, and unnormalized choropleth. For the sixteen states that mapped normalized data only, we further examined their normalization methods. This follow-up evaluation identified if other cartographic principles regarding map symbology in a thematic map were followed, such as the number of classes, color schemes, and enumeration units. Table 2 shows the results: (1) the most popular normalization method was a ratio of cases in an enumeration unit ($n = 14$, 87.5%); only two states (12.5%) employed different normalization methods: California was based on a 7-day risk level, and South Dakota was based on the

Table 1. Thematic map types and data normalization status on state COVID-19 dashboards.

State	Map type	Using unnormalized choropleth maps	Variable(s)	Number of classes	Color schemes (low to high)	Enumeration unit
Alabama[a]	Choropleth	Yes	Total cases	7	Blue	County
Alaska[a]	Choropleth	Yes	Total cases	Continuous	Red	Borough/Census Area
Arizona[a]	Choropleth	Yes	Total cases	No data	Red	County
Arkansas	Choropleth	Yes	Total Cases	Continuous	Blue	County
California	Choropleth	No	Risk level (based on 7-day positivity rate)	4	Yellow to purple	County
Colorado	Choropleth/ Proportional symbol	No	Cases per 100,000 population	Continuous	Blue	County
Connecticut	Choropleth	No	Cases per 100,000 population	2	Grey to red	Town
Delaware	Choropleth	No	7-day cases per 100,000 population	6	Blue	Zip Code
Florida	Choropleth	Yes	Total cases	No data	Yellow to Blue	County
Georgia	Choropleth	No	14-day cases per 100,000 population	Continuous	Yellow to Red	County
Hawaii[a]	Choropleth	Yes	14-day total cases	5	White to orange. One no-data class	Zip Code
Idaho	Choropleth	Yes	Total cases	No data	White to orange	County
Illinois	Choropleth	Yes	Total cases	No data	Blue	Zip code
Indiana[a]	Choropleth	Yes	Total cases	No data	White to orange	County
Iowa	Choropleth	No	14-day cases per 100,000 population / 7-day cases per 100,000 population	5	Blue	County
Kansas	Choropleth	Yes	Total cases	No data	Blue	County
Kentucky[a]	Choropleth	No	7-day cases per 100,000 population	4	Green to red	County
Louisiana	Choropleth	Yes	Total cases	4	Blue	Census Tract
Maine	Choropleth	Yes	Total cases	4	Pink	Zip Code
Maryland	Choropleth	Yes	Total cases	3	Blue	County
Massachusetts	Choropleth	Yes	Total cases	5	Blue	County
Michigan[a]	Choropleth	Yes	Total cases	5	Blue	County
Minnesota	Choropleth	Yes	Total cases	7	Blue	County
Mississippi[a]	Choropleth	Yes	7-day cases per 100,000 population	5	Blue	County
Missouri	Choropleth	No	Cases per 100,000/7-day cases per 100,000 population	Continuous	Red to orange	Jurisdiction (Appears to be county)
Montana	Choropleth	Yes	Total active cases	4	Blue	County
Nebraska	Reference map	N/A	N/A	N/A	N/A	County
Nevada	Choropleth	No	Cases per 100,000 population	6	Blue	County
New Hampshire	Choropleth	Yes	Total cases	6	Red to orange. One no-data class	Town
New Jersey	Choropleth	Yes	New daily cases	7	Blue	County
New Mexico	Choropleth	Yes	Total cases	Continuous	Green	County
New York	Choropleth	Yes	Total cases	7	Orange	County
North Carolina[a]	Choropleth	Yes	Total cases	5	Blue	County and Zip Code
North Dakota[a]	Choropleth	Yes	Total cases	No data	Red	County
Ohio	Choropleth	Yes	Total cases	No data	Blue	County
Oklahoma	Choropleth	Yes	Total cases/total deaths/total recovered	Continuous	Yellow Red Green	County
Oregon	Choropleth	No	Cumulative cases divided by population	5	Blue	County
Pennsylvania	Choropleth	No	Cases per 100,000 population	5	Red	County
Rhode Island	Choropleth	No	Cases per 100,000 population	6	Yellow to blue	Geographic Area or municipalities
South Carolina	Choropleth	No	Cases per 100,000 population	5	Blue	County
South Dakota	Choropleth	No	Community spread (totals)	3	Blue	County
Tennessee	Choropleth	No	Positive tests per 100,000 population	Continuous	Blue and red	County
Texas	Proportional symbol	N/A	Total Cases	Continuous	N/A	County
Utah	Choropleth	No	14-day case rate per 100,000 population	7	Yellow to red	County
Vermont	Choropleth	Yes	Total cases in the past 14 days	No Data	blue	County
Virginia	Choropleth	Yes	Total cases	6	blue	County
Washington	Choropleth	Yes	Total cases	6	Blue	County
West Virginia[a]	Choropleth	Yes	Total cases in past 7 days	No data	Blue	County
Wisconsin[a]	Choropleth	Yes	Total cases	4	Grey	County
Wyoming	Proportional symbol	NA	Total cases	Continuous	N/A	County

[a]Indicates a state where we observed both normalized and unnormalized choropleth maps.

community spread rates (2) We found that the majority of states with normalized choropleths on their dashboards ($n = 12$, 75.0%) employed discrete class breaks, while four of these states (25.0%) used a continuous color scheme. Choosing map symbology is more flexible than the need for data normalization but still demands scrutiny from a cartographic perspective (Monmonier, 2018). Generally, the literature suggests using discrete class breaks over continuous color schemes for making a thematic map, as it is easier to discern the difference between data values (Brewer & Pickle, 2002; Dobson, 1973; Krygier & Wood, 2005). (3) When mapping with discrete class breaks, a general rule is to have no less than three and no more than seven classes best to distinguish classified data values (Harrower & Brewer, 2003). This rule was followed by ten (91.7%) of the eleven states mapping only normalized data and discrete class breaks, with most maps having five classes. (4) In terms of color hues, seven of the states mapping only normalized data (43.8%) employed a cold color hue (e.g. green, blue, and purple), five (31.3%) employed a warm color hue (e.g. red, orange, yellow), and four (25.0%) had a mixed use of cold and warm colors. (5) For enumeration units, twelve (75.0%) used county, Delaware used ZIP codes, Connecticut and Rhode Island used local enumeration units such as town or municipality, and Missouri used 'Jurisdictions,' which upon inspection appeared to correspond to the county boundaries.

The choice of enumeration unit is critical. Due to the modifiable aerial unit problem (MAUP), different ways of subdividing an area can influence the final aggregate values (Chen et al., 2022). Counties in many states are administrative units where policy is made. In some smaller states, like Connecticut and Rhode Island, counties are often ignored in favor of smaller administrative units, such as towns (Chen et al., 2021). These smaller units allow for finer-scale analysis. ZIP codes, like towns, are also generally smaller than counties; however, their use in epidemiological mapping is controversial (Chen et al., 2022). ZIP codes are often discontinued or modified, do not cover the entire United States, and their representation as polygons is often not representative of what they cover (Grubesic & Matisziw, 2006). Therefore, ZIP codes for the analysis of health data should be avoided, if possible in favor of census tracts or another more meaningful enumeration unit, and used cautiously in consideration of their limits only when unavoidable (Chen et al., 2022; Grubesic & Matisziw, 2006).

Next, we reviewed the unnormalized maps of the thirty-one states mapping totals in choropleths to see if the state dashboards followed other cartographic principles regarding map symbology. Below are our findings: (1) the most mapped variable was cumulative cases per enumeration unit ($n = 25$, 80.6%), two states (6.5%) mapped total cases in 7-day windows, and two states mapped total cases in 14-day windows. New Jersey mapped total daily cases, and Montana mapped 'total active cases.' (2) We found that the majority of states with unnormalized choropleths on their dashboards ($n = 17$, 54.0%) employed discrete class breaks. In comparison, four states (12.9%) used a continuous color scheme. As previously stated, the general consensus is that a discrete color scheme may be more easily understood than a continuous one. We have no data on class breaks for ten (32.3%) of these states due to missing legends. (3) All seventeen states employing discrete class breaks used between three and seven classes, with most maps using five class breaks, all aligning with the categorizing pricinple of using 3–7 classes. (4) In terms of color hues, twenty states (64.5%) employed a cold color hue (e.g. green, blue, and grey), ten states (32.2%) employed a warm color hue (e.g. red, orange, yellow), and one state (3.2%) had a mixed use of cold and warm colors. (5) As for enumeration units, twenty (80.6%) used county, three (9.6%) used ZIP codes, New Hampshire used local enumeration units of town, and Alaska used the local unit of 'Borough/Census Area.' North Carolina had both county and ZIP codes available as options for users to map the case data; however, as the county was the default visualization, we counted as using them. One state, Louisiana, used census tracts in their published maps. As census tracts are smaller than counties, used throughout the United States, and created with consideration of human populations, this choice is highly in line with recommendations in the literature. Surprisingly, among all 50 states, only Louisiana created maps using census tracts at this point in the pandemic.

For the three states that did not use choropleth maps on their dashboards (i.e. Nebraska, Texas, and Wyoming), all mapped using counties. Texas and Wyoming employed continuous class breaks for their proportional symbols, which were blue circles. Nebraska's map did not show COVID-19-related data at the time of the survey.

On April 8, 2023, nine days after the United States Senate voted to end the COVID-19 emergency declaration, we reviewed the list of URLs and dashboards we used in this study. First, we confirmed that the CDC and Prevention COVID-19 data tracker we based Figure 1 on still allowed users to view choropleth maps displaying total cases; however, a normalized option still exists, as previously observed (Centers for Disease Control and Prevention, 2021). Next, we found that thirteen (26%) of previously identified state dashboard URLs no longer led to a publicly facing dashboard (Table 2). Five enforced a sign-in procedure for map viewing, while the others were unavailable. It is likely that as time progresses, more of these links will no longer function, contiributing to a phenomenon known as link rot (Klein et al., 2014).

Table 2. Availability of the URLs for state COVID-19 dashboards.

State	URL at the time of the survey (February 11th, 2021)	URL availability on follow-up (April 8, 2023)
Alabama	https://alpublichealth.maps.arcgis.com/apps/opsdashboard/index.html#/6d2771faa9da4a2786a509d82c8cf0f7	Yes
Alaska	https://alaska-coronavirus-vaccine-outreach-alaska-dhss.hub.arcgis.com/app/6a5932d709ef4ab1b868188a4c757b4f	No[a]
Arizona	https://www.azdhs.gov/preparedness/epidemiology-disease-control/infectious-disease-epidemiology/covid-19/dashboards/index.php	Yes
Arkansas	https://experience.arcgis.com/experience/c2ef4a4fcbe5458fbf2e48a21e4fece9	No[a]
California	https://covid19.ca.gov/state-dashboard/	Yes
Colorado	https://covid19.colorado.gov/data	Yes
Connecticut	https://portal.ct.gov/Coronavirus/COVID-19-Data-Tracker	Yes
Delaware	https://coronavirus.delaware.gov/	Yes
Florida	https://experience.arcgis.com/experience/96dd742462124fa0b38ddedb9b25e429	No[a]
Georgia	https://dph.georgia.gov/covid-19-daily-status-report	Yes
Hawaii	https://health.hawaii.gov/coronavirusdisease2019/what-you-should-know/current-situation-in-hawaii/#cases	Yes
Idaho	https://public.tableau.com/profile/idaho.division.of.public.health#!/vizhome/DPHIdahoCOVID-19Dashboard/Home	Yes
Illinois	https://www.dph.illinois.gov/covid19/covid19-statistics	No
Indiana	https://www.coronavirus.in.gov/2393.htm	Yes
Iowa	https://coronavirus.iowa.gov/pages/case-counts	No
Kansas	https://www.coronavirus.kdheks.gov/160/COVID-19-in-Kansas	Yes
Kentucky	https://kygeonet.maps.arcgis.com/apps/opsdashboard/index.html#/543ac64bc40445918cf8bc34dc40e334	Yes
Louisiana	https://ldh.la.gov/Coronavirus/	Yes
Maine	https://www.maine.gov/dhhs/mecdc/infectious-disease/epi/airborne/coronavirus/data.shtml	Yes
Maryland	https://coronavirus.maryland.gov/	Yes
Massachusetts	https://www.mass.gov/info-details/community-level-covid-19-data-reporting	Yes
Michigan	https://www.michigan.gov/coronavirus/	Yes
Minnesota	https://www.health.state.mn.us/diseases/coronavirus/situation.html	Yes
Mississippi	https://msdh.ms.gov/msdhsite/_static/14,21882,420,873.html	No
Missouri	https://showmestrong.mo.gov/public-health-county/	Yes
Montana	https://montana.maps.arcgis.com/apps/MapSeries/index.html?appid=7c34f3412536439491adcc2103421d4b	Yes
Nebraska	https://experience.arcgis.com/experience/ece0db09da4d4ca68252c3967aa1e9dd/page/page_0/	No[a]
Nevada	https://nvhealthresponse.nv.gov/	Yes
New Hampshire	https://www.nh.gov/covid19/dashboard/case-summary.htm	Yes
New Jersey	https://www.nj.gov/health/cd/topics/covid2019_dashboard.shtml	Yes
New Mexico	https://cvprovider.nmhealth.org/public-dashboard.html	Yes
New York	https://covid19tracker.health.ny.gov/views/NYS-COVID19-Tracker/NYSDOHCOVID-19Tracker-Map?%3Aembed=yes&%3Atoolbar=no&%3Atabs=n	No
North Carolina	https://covid19.ncdhhs.gov/dashboard	Yes
North Dakota	https://www.health.nd.gov/diseases-conditions/coronavirus/north-dakota-coronavirus-cases	Yes
Ohio	https://coronavirus.ohio.gov/wps/portal/gov/covid-19/dashboards/overview	Yes
Oklahoma	https://looker-dashboards.ok.gov/embed/dashboards/44	No
Oregon	https://experience.arcgis.com/experience/fff9f83827c5461583cd014fdf4587de	No[a]
Pennsylvania	https://www.health.pa.gov/topics/disease/coronavirus/Pages/Cases.aspx	Yes
Rhode Island	https://ri-department-of-health-covid-19-data-rihealth.hub.arcgis.com/	Yes
South Carolina	https://scdhec.gov/covid19/sc-testing-data-projections-covid-19	No
South Dakota	https://doh.sd.gov/COVID/Dashboard.aspx	Yes
Tennessee	https://www.tn.gov/health/cedep/ncov/data/maps.html	Yes
Texas	https://txdshs.maps.arcgis.com/apps/opsdashboard/index.html#/ed483ecd702b4298ab01e8b9cafc8b83	No
Utah	https://coronavirus.utah.gov/case-counts/	Yes
Vermont	https://www.healthvermont.gov/covid-19/current-activity/vermont-dashboard	Yes
Virginia	https://www.vdh.virginia.gov/coronavirus/coronavirus/covid-19-in-virginia-cases/	Yes
Washington	https://www.doh.wa.gov/Emergencies/COVID19/DataDashboard#dashboard	Yes
West Virginia	https://dhhr.wv.gov/COVID-19/Pages/default.aspx	Yes
Wisconsin	https://www.dhs.wisconsin.gov/covid-19/data.htm	Yes
Wyoming	https://health.wyo.gov/publichealth/infectious-disease-epidemiology-unit/disease/novel-coronavirus/covid-19-map-and-statistics/	No

[a]Indicates a dashboard URL now points to an ArcGIS Online sign-in page, and thus may still exist there but be unavailable.

3. Discussion and conclusion

Since the outbreak of the COVID-19 pandemic, Web GIS technologies, particularly dashboards, have provided unprecedented opportunities for sharing health information. Choropleth maps are overwhelmingly favored to visualize COVID-19 case data in these dashboards (Mooney & Juhász, 2020). Unfortunately, our findings reveal that more than half of the states did not rigorously follow fundamental cartographic principles, such as data normalization, to create thematic maps. Even among those states that mapped with appropriate data, we identified other cartographic issues, such as less-than-ideal numbers of classes, color schemes, and inappropriate choice of enumeration units. These findings raise serious concerns regarding Web mapping as they serve as an authoritative outlet for delivering health information. The lack of adherence to cartographic principles in map creation could unexpectedly mislead public perception of the pandemic's impact (Engel et al., 2022; Geyer & Lengerich, 2023). If these dashboards were used to assist policymakers, there is a possibility that a biased epidemiological pattern arising from the maps could have a lasting policy impact. This review helps to showcase the extent of these problems as part of the infodemic surrounding COVID-19.

On the other hand, we see positive changes in the creation of dashboards. For instance, while mapping totals, the Florida dashboard included a note to the user that 'comparison of counties is not possible because case data are not adjusted by population' (Florida Department of Public Health, 2021). Similarly, Connecticut initially used unnormalized data in its dashboard but later switched to normalized data in its latest version (Adams et al., 2020).

Beyond normalizing data in choropleth maps, many other methods could be employed to improve the interpretation of epidemiological data, such as the cartogram, to show the severity of a health outcome, where the areal unit is altered proportionally to the population density affected (Roth et al., 2010; Tobler, 2004; Zhang, 2020). A complementary approach when using dynamic web maps is to incorporate additional information (such as total cases and total population) in a pop-up window to present a more comprehensive view of the health data when a user clicks on an enumeration unit (Thomas et al., 2022). Similarly, other visualization methods, such as dot density maps, hot spot maps based on Getis Ord Gi* statistic, and relative risk cluster maps created using Poisson space–time scan statistic, can also be employed (Dent, 1990; Desjardins et al., 2020; Getis & Ord, 1992). These visualization and statistical techniques can open new avenues to displaying epidemiological data from multifaceted perspectives without using a choropleth to display absolute values.

This article focuses on observing choropleth maps and whether they adhere to established cartographic conventions on United States State government official dashboards. Our findings are consistent with other studies that have identified widespread misuse of choropleths throughout the pandemic (Adams et al., 2020; Engel et al., 2022; Everts, 2020; Kronenfelda & Yoo, 2020). With this article, we hope that public health agencies may take the necessary steps to monitor how data are collected (Tao et al., 2020), comply with map-making principles, and integrate other important demographic metrics, such as age and sex, when making maps (Kontis et al., 2020). Importantly, we suggest that health professionals, policymakers, and cartographers should be included in the discussion when constructing these public-facing web maps (Plewe, 2007; Rushton et al., 2000). These combined efforts may help improve health communication in future health crises as we are normalizing life with this pandemic.

Software

All figures were produced using ESRI ArcMap 10.7.1.

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Disclosure statement

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Data availability

We collected dashboard data on February 11, 2021, from the United States State government dashboards. We revisited this dataset on April 8, 2023, to determine the number of links that were still active. Boundary files were sourced from the United States Census Bureau. The COVID-19 case data were obtained from the CDC at https://www.cdc.gov/coronavirus/2019-nCoV/index.html.

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