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CASE STUDY

Mapping COVID-19: Applying Ethical Strategies in Web Mapping Decisions

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In December 2019, the world was introduced to a coronavirus, the likes of which have never been seen before, resulting in the COVID-19 pandemic. During the initial months of the pandemic, academics, government agencies, and concerned citizens, among others, raced to generate maps to help explain the geographic spread of the virus over space and time. Maps, however, can be intentionally or unintentionally misleading; we saw this play out during the pandemic as we rushed to make COVID-19 dashboards and online maps. While the Johns Hopkins University's COVID-19 dashboard served as the first authoritative resource on the pandemic, it lacked the spatial granularity required for smaller states, such as Connecticut. Realizing this limitation, a team of geography Ph.D. students and faculty came together to develop a dashboard better suited to serve the residents of the state and aid policymakers during a time when each decision could have vast consequences. This case study reflects on our team's strategies to address the ethical considerations to deliver high-quality maps and to promote healthy skepticism among users of the COVID-19 dashboard. We first provide a historical background of the discussion around ethics in cartography that we used to frame our arguments and strategies. Second, we summarize our deliverables, starting with an online interactive dashboard for 169 towns suitable for both mobile and desktop viewing. For the visualizations, we tried to balance the right amount of health information so that they were cartographically sound, easy to understand, and not misleading. As geographers, this is one of our responsibilities to our communities.

KEYWORDS: dashboards; ethics; map design; internet activists; Monmonier's six strategies; online maps

INTRODUCTION

Wake up, go downstairs to make coffee, boot up the work computer, open ArcGIS Pro, and start a geoprocessing function that will take a few minutes to run. While ArcGIS Pro runs, go online to look at social media for a few minutes while finishing your coffee. During the height of the COVID-19 pandemic in 2020, this routine became the new normal for many geographic information system (GIS) professionals, and that is where this case study in cartographic ethics begins. With algorithm-curated social media feeds and the widespread proliferation of open-source GIS software, COVID-19 web-based maps inevitably ended up in the social media feeds of cartographic professionals. To the chagrin of many, several of these maps did not follow even the most basic cartographic conventions based on decades of research, such as normalizing choropleth maps, use of appropriate enumeration units, and appropriate use of color (Adams et al. 2023).

Tremendous amounts of work have been done to properly implement GIS principles, including establishing consistent data standards, best practices for visualizations, the role of web maps in communication, and how to implement the technology (Jenks 1953; Peng and Tsou 2003; Zhang and Li 2005; DeMers 2009; Fu and Sun 2011; Zhang et al. 2015; Brewer 2016; Kuria et al. 2019). Today, in spite of this body of literature, anyone with a computer, access to the Internet, and publicly-available data can create a web-based map without properly adhering to the best practices of mapmaking. Since such maps can be distributed widely using social media, expanding the utility of GIS to more people (Plewe 1997; 2007; Trainor 2023) has created scenarios where maps can be misinterpreted or can spread misinformation.

Without any way to enforce the best practices established over decades of research, users are under no obligation to read instructions or follow tutorials (Peterson 2008). Thus, unfortunately, the best thought-out cartographic practices and theories often do not leave academia and are not implemented by GIS users. While holding all GIS users to professional standards is impossible, and we can forgive middle-school book reports and personal social media pages for cartographic errors, mapmaking and GIS lack occupational licensure in the United States, resulting in poorly made maps being published and distributed by federal and state governments (Adams et al. 2020; Monmonier 1985a). Poorly made maps can mislead the public, which is unethical, and they can lead to serious negative consequences when used to inform decisions related to public health crises, like the COVID-19 pandemic. The democratization of cartography, i.e., making maps easily available, while tremendously advantageous, has opened Pandora's box for an infodemic, spread by the share button through screens and smartphones. Academia and professionally trained cartographers were well aware of these plausible problems with cartography long before the COVID-19 pandemic (Harrison 1950; Jenks 1981; Monmonier 1985b; 2018; Clarke 1995; Monmonier 1985a; Jenks 1953).

In his 1991 paper titled "Ethics and Map Design: Six Strategies for Confronting the Traditional One-Map Solution," Mark Monmonier calls for "a conscious effort by map authors and cartographic educators to promote informed skepticism among map viewers." Physicists or statisticians, for example, exercise their disciplinary responsibility by informing the general population about the wrong applications of laws or statistical functions to minimize misinformation and potential harm to society. Cartographers and GIS users should not only promote ethics and best practices of mapmaking, but also critically review maps that did not follow any standards. Every time a poorly made map comes across our feed on social media, it is an opportunity to promote informed skepticism among map viewers, and it is our ethical responsibility as mapmakers to do so even though this may seem an exercise in futility. A well-thought-out comment is unlikely to gain the same attention as the map itself, and often, well-meaning criticisms are overwhelmed by others defending the original map. After attempting this a few times, one can start to feel that it is easier to keep scrolling. But then the problem persists. During the early stages of the COVID-19 pandemic, we witnessed a proliferation of web-based maps depicting many different aspects of the spread of the pandemic. In spite of cartographic educators promoting informed skepticism among map viewers, the usage of poorly made web-based maps and their dissemination via social media led to spread of misinformation on a novel virus. Some have argued that there was a corresponding infodemic, partially spread by bad maps (Mooney and Juhász 2020). Research has demonstrated that these maps influenced the public's perception of the pandemic, specifically causing rural individuals to falsely believe COVID-19 was mostly an urban problem (Engel et al. 2022). Misinformation leading individuals to underestimate their personal or community risk can have ramifications, and research suggests it may have contributed to political polarization on these issues (Engel et al. 2022).

The Johns Hopkins University dashboard served as the first authoritative online, continuously updated, map-based tool on the COVID-19 pandemic, but because it displayed county-level data for the US, it lacked the spatial granularity required for smaller US states, such as Connecticut (Dong et al. 2020; Everts 2020; Mooney and Juhász 2020). With only eight counties in a state of about 3.5 million people (Census 2020), any information represented at the county-level scale was not helpful when community-based organizations (CBOs) and administrative services made day-to-day decisions for their towns. Realizing this need, frustrated with rampant poor and unhelpful maps online, and attempting to fulfill our disciplinary and ethical duty to set an example and promote map literacy and skepticism, we created the University of Connecticut **Department of Geography's COVID-19 Mapping Project for Connecticut** for the state's 169

towns. Using towns, rather than counties like many other states, was particularly important in hindsight, as the state of Connecticut has now completely replaced counties with nine planning regions that do not correspond to the previous counties.

The project focused on creating various visualization approaches to explore and communicate COVID-19 data published in Connecticut. Among the outcomes of this project, our team members published papers calling attention to, and documenting, cartographic issues in official United States federal and state COVID-19 dashboards, such as the lack of proper normalization in choropleths (Adams et al. 2020; Adams et al. 2023). Other papers we published made use of the Connecticut COVID-19 datasets to model the disease using town-level data and assess the deployment of vaccines in the state among vulnerable populations (Chen et al. 2021; Wang et al. 2021). Collectively, we presented our work at local, regional, national, and international conferences, including the UConn Center for mHealth and Social Media conference focusing on COVID-19: Media, Misinformation, and Science Communication. We included discussion of our work in class material in our department, and we brought our work to the attention of medical professionals in presentations at Connecticut Children's Hospital. Several GIS professionals across the country took similar, or far greater, action to try and bring attention to the bad maps that appeared during the pandemic and set examples of how the maps should look, fulfilling the ethical responsibility of cartographers proposed by individuals like Mark Monmonier (1991) and Jeremey Crampton (1995).

CASE STUDY: UCONN DEPARTMENT OF GEOGRAPHY'S COVID-19 MAPPING PROJECT, MARCH 2020–APRIL 2023

This case study reflects on the work of our team to address our responsibility to deliver high-quality maps and information that would promote healthy skepticism among the users of the COVID-19 dashboard in Connecticut. Often, cartographic theory is not incorporated into practice by GIS users, so to avoid making ethical blunders, we tried to justify every cartographic decision we made with a citation. We were guided by the six strategies from Monmonier's 1991 paper, "Ethics and Map Design: Six Strategies for Confronting the Traditional One-Map Solution," and below we use them to describe selected ethical quandaries or dilemmas and our responses or workarounds. Monmonier's six strategies are: (1) dynamic sequencing of different cartographic views, (2) creating experiential maps, (3) abiding by professional standards, with a Code of Cartographic Ethics calling for presenting alternative views, (4) disclosing experiments, (5) promoting informed skepticism among map viewers, and (6) institutional structures (Monmonier 1991). During our project, these strategies served as a framework to help guide our decisions, workflows, and goals, while giving us a broader justification for what we were doing, including the use of an interactive dashboard over more traditional static cartography. These strategies served to help us avoid contributing to the spread of misinformation.

We addressed Monmonier's strategies #1 and #3 by implementing what Monmonier called "atlas touring" using a variety of spatial visualizations, graphs, and charts that we adapted throughout the pandemic (Monmonier 1991). These were divided into two products: an online COVID-19 dashboard and a policy-based visualization. Using an Esri dashboard app, with the Johns Hopkins dashboard as inspiration, we created a dashboard that was updated daily for the state of Connecticut. Throughout the pandemic, the topics of the web maps and visualizations hosted on our dashboard varied. We created and published choropleth maps, proportional symbol maps, dot density maps, pie chart maps, line graphs, bar charts, and raw number values. Many of the maps had dynamic scales (that is, they were zoomable) and pop-ups, allowing users to engage with the maps and see the raw data for themselves. Notably, we provided a town-level map of case rate (per 10,000 people) over the previous two weeks based on the (known) incubation period of the COVID-19 infection, which was unique and was not provided by any other COVID-19 tracking systems in the state. Later, when vaccination efforts were underway, we created a map (Figure 1) that showed the percentage of the population fully vaccinated by town and placed a star symbol on the centroid of towns that had reached 70% coverage for "herd immunity," based on the best information at the time (Plans-Rubió 2022). This was later replaced with an interactive web slider (Figure 2) embedded in the main dashboard that facilitated comparison of full vaccination and first dose percentages by town. To incorporate the time variable, we used two different animations: a dot density map showing total cases, and a pie chart depicting vaccination status by town. Later, we used

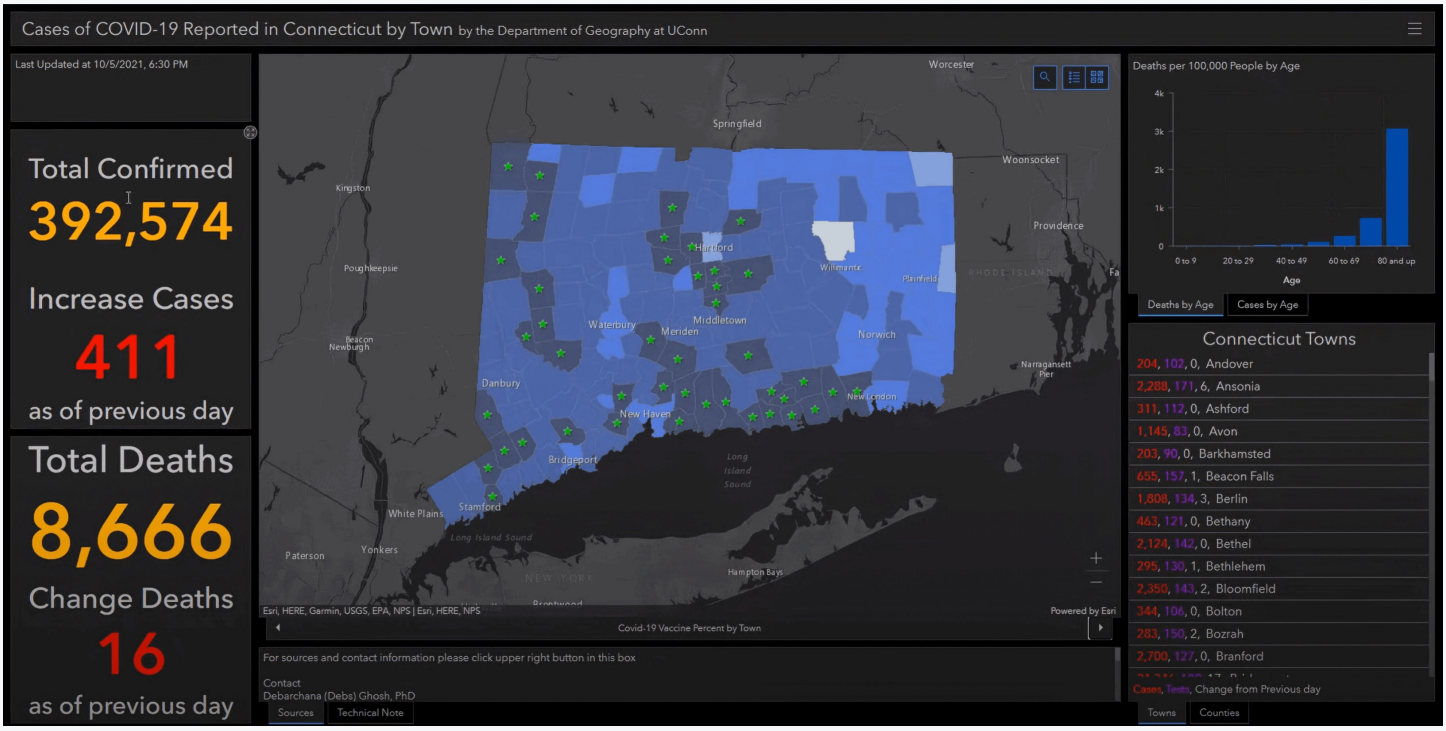

Figure 1. Percent of population fully vaccinated.

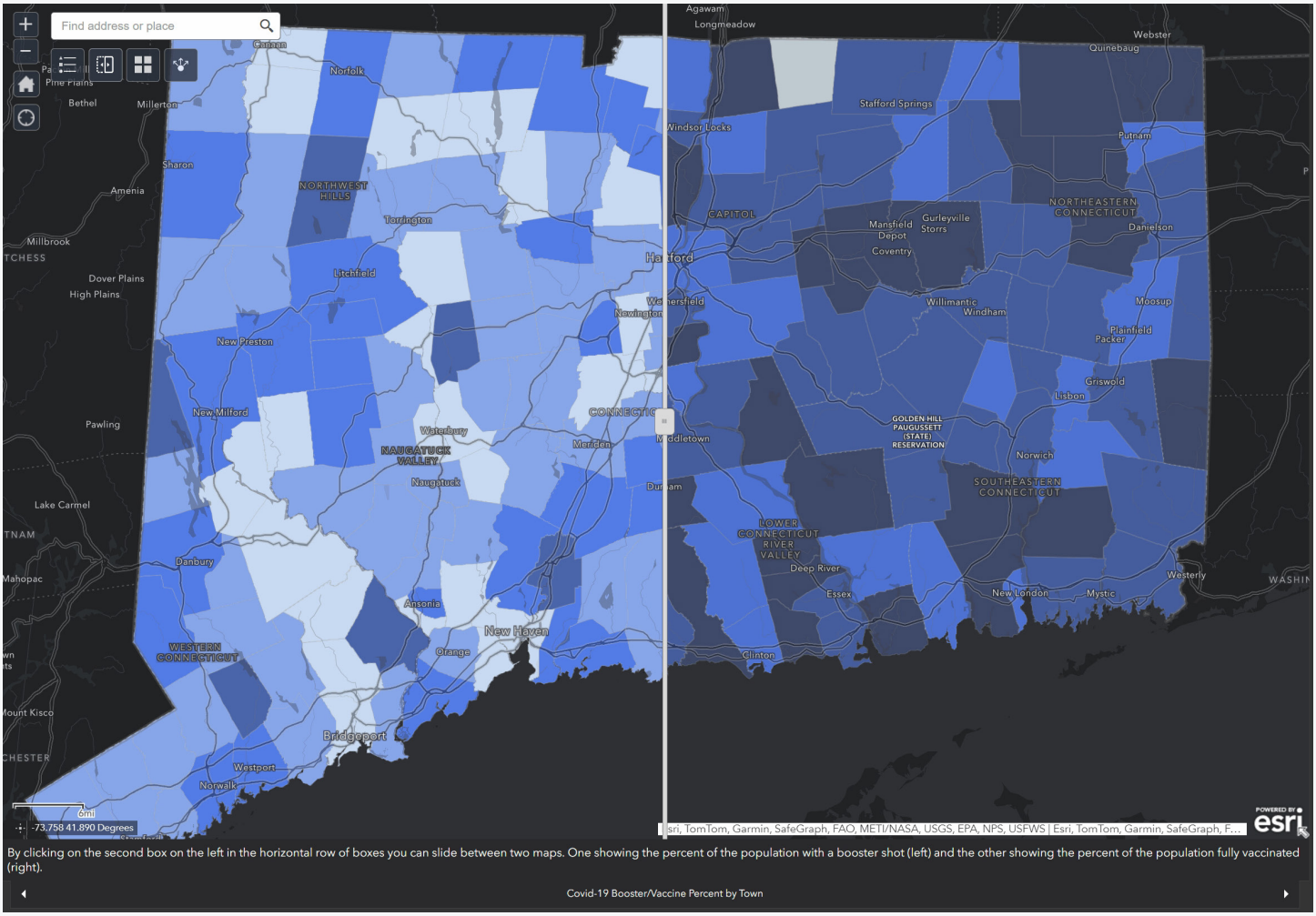

Figure 2. Percent of population fully vaccinated, with slider.

a swipe tool to compare variables related to COVID-19 vaccination side by side on the map.

Realizing the importance and the potential impact of the executive orders of Governor Ned Lamont, and other landmark intervention and mitigation efforts at the national level, such as the CDC's mask usage guidelines and the vaccine rollout, we developed our second product using open-source resources like Shiny in R and JavaScript. This was an interactive website, "Visualizing Associations between Policy Decision Timeline and COVID-19 Infection for Connecticut" (Figure 3). The timeline on the website showed the subsequent major COVID-19 related executive orders and mitigation measures, re-openings of schools, restaurants, and vaccination roll-out undertaken by the state of Connecticut after the first case appeared on March 6th, 2020, and the first executive order of "state emergency" was declared on March 10th, 2020.

Over time we adapted our dashboard items with "experiential maps," per Monmonier's strategy #2, to meet the changing conditions of the COVID-19 pandemic and its mitigation efforts. Early on in the pandemic, when testing was the number one priority, we made sure to include the location and associated information related to testing sites in Connecticut. When it was time to make decisions about returning to school in the fall of 2020, we incorporated the location of all state universities in Connecticut so that users could readily understand the COVID-19 conditions in the university towns. When the vaccine rollout started in February 2021, we added a pie chart showing weekly trends in the percentage of unvaccinated, first-dose, and fully-vaccinated people by town. In Figure 3, the timeline depicting the governor's executive orders and policies is interactive and allows users to click on various orders/policies to see what the situation was like on the date it was implemented. From a historical perspective, we hope that this can give insight to the impact of health policies/mitigation measures on the spread and transmission of COVID-19 cases. This could be useful for future infectious diseases outbreaks.

Our team attempted to proactively implement Monmonier's strategy #3, providing alternate views, during weekly discussions over Zoom, during which we discussed each visualization, proposed possible additional ones, and tried to be as careful as possible in our cartographic decision making. We also discussed issues related to COVID-19 health disparities, the lack of data by race/ethnicity and gender, and the incident of an **alleged whistleblower** who was a geographer and a GIS analyst at Florida's Department of Public Health regarding data aggregation and curation. These experiences and interactions, and our teamwork, led to the overall growth and maturity of the "cartographers" in us while we lived through a public health crisis.

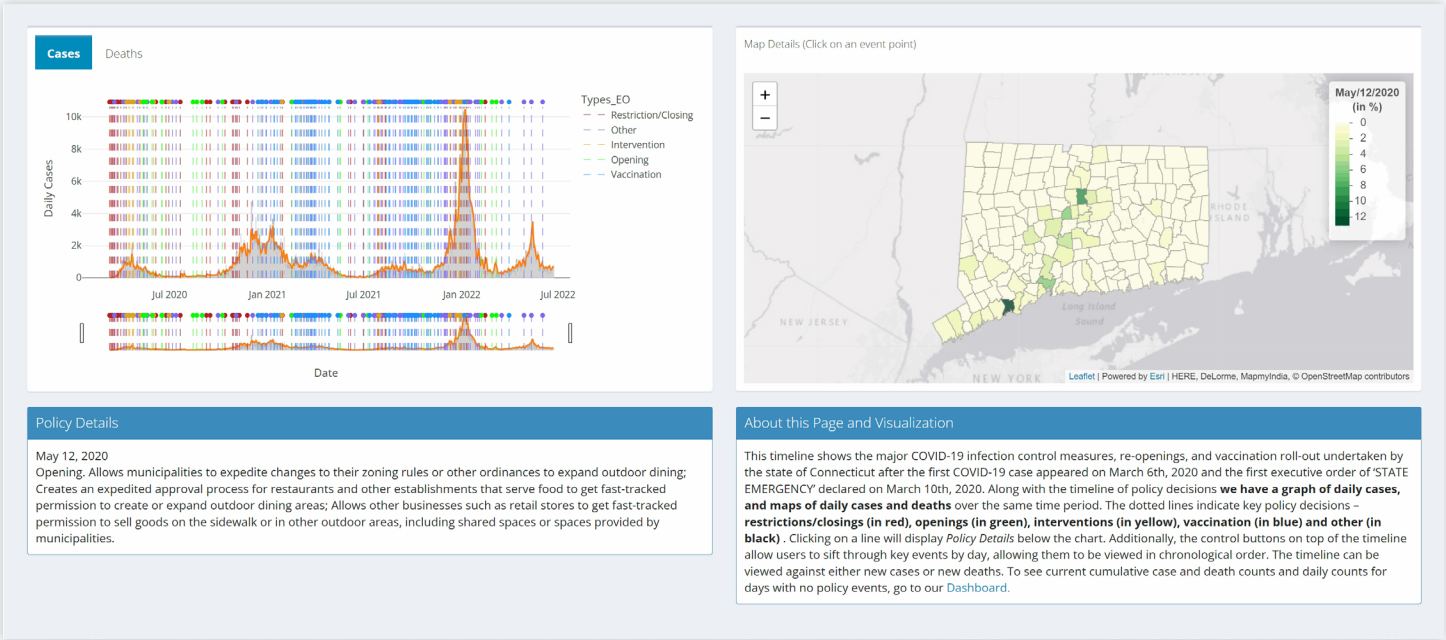

Figure 3. Visualizing associations between policy decisions and COVID-19 infection in Connecticut.

We tried to implement Monmonier's strategy #4, "disclosing experiments," in several ways. We documented our data processing decisions, and we have included a discussion of our mapmaking decisions in the methodology section of forthcoming papers. One example of the need to document data curation arose when the state of Connecticut shifted from publishing daily case counts for weekends, to publishing Saturday and Sunday added onto Monday's numbers. To continue logging daily counts and remedy this problem, we divided the Monday case count by three, and equally attributed it to Saturday, Sunday, and Monday. While this was not ideal, because we were forced to assume without evidence that the number of COVID-19 cases was same on all the three days, it was the only way to maintain daily case counts for analysis. To our surprise, another department at UConn noticed that Saturday, Sunday, and Monday were always equal, and contacted us with their concerns. This decision was documented, so that we could share these limitations with our users.

As another example, daily case counts for a town could be negative values because officials would periodically adjust the number of previously recorded cases, thus lowering the town's case count. In these instances, we resorted to changing the negative values to zeros for the daily visualizations to mitigate the confusion associated with a daily negative case count. However, these adjustments resulted in massive outliers in some instances, which we needed to either exclude from our analysis, or adjust for. These changes had to be documented very carefully to avoid misunderstandings or accusations that we were manipulating the data to suit a particular narrative. In hindsight, one strategy to maintain full disclosure would have been to capture a screenshot of the web map at regular intervals and include it in the documentation. Because web maps can be changed by the organization maintaining them—removing yesterday's mistakes and patterns that may have influenced policy being implemented today—and are also subject to link rot, this type of documentation could have captured the changes we made and provided more transparency.

We tried to implement Monmonier's strategy #5, "promoting informed skepticism among map viewers," in multiple ways. First, we published papers discussing problems with the official government dashboards, explicitly focusing on the normalization of choropleth maps and the colors and enumeration units used to make them. We presented papers and posters on these subjects at several academic conferences, workshops at the Connecticut Children's Hospital, and courses at University of Connecticut. Among these presentations was a YouTube video poster prepared for the "**COVID-19: Media, Misinformation, and Science Communication**" conference organized by the UConn Center for mHealth and Social Media. Many of these activities can also be seen as satisfying Monmonier's strategy #6, which calls for using "public forums, a journal of cartographic criticism, or courses promoting systematic critiques of maps, especially potentially persuasive maps" to get feedback on map design (Monmonier 1991). During the project, we reviewed other dashboards and web mapping projects, and we presented issues we found with those maps at conferences and as a write-up in the *Journal of Maps* (Adams et al. 2023). Members of our the project group were interviewed by NBC Connecticut, during which they discussed the potential for web maps on our dashboard to facilitate understanding of the COVID-19 case data (Jones 2020).

Figure 4 shows data and different frames from our dashboard to support our narrative of why and how we used Monmonier's strategies to help us avoid contributing to the spread of misinformation. This figure demonstrates the impact of symbolization (choropleth vs dot density), normalization (rate vs total cases), and the modifiable areal unit problem (MAUP) based on scales of geography (towns, counties, and planning regions) on the way spatial patterns appear on a map (Openshaw 1977; Fotheringham 1989).

DISCUSSION (AND A CALL TO ACTION)

The activities of the members of the COVID-19 Mapping Project for Connecticut, which is detailed in this case study, are just a tiny snapshot of the work carried out by geographers and cartographers across the country. During the COVID-19 pandemic, in spite of spread of information via poorly designed maps, the larger GIS community tried to demonstrate our technology's capabilities to study and map a pandemic in near real time to inform

policy (Dong et al. 2020; Delmelle et al. 2024). However, at the federal and state government levels, there were major failures to adhere to the most basic of cartographic standards, including failure to use appropriate symbolization or enumeration units (Adams et al. 2020; Adams et al. 2023). These failures can erode the trust that people place in maps, which can potentially cost lives when those maps are needed to coordinate the response to disasters. Ultimately, all society can do now is evaluate how GIS was used during the COVID-19 pandemic, assess the strengths and failures of those uses, and try to take an active role in ethically implementing the technology in the future. Moving forward, if nothing else, we can use the examples of misinformation spread by official government COVID-19 maps to underscore the importance of cartographic conventions.

Crampton (1998) calls for GIS professionals to be "Internet activists" in spreading good content online, and set the tone in regard to employing GIS and cartography online (Crampton 1998; McGranaghan 1999). Perhaps those of Mark Monmonier's "cartographic priesthood" must take this activism a step further and implement his strategies for ethics in map design by engaging with the comment section on social media as cartographic critics, insist on adherence to cartographic standards wherever possible, and patiently try to spread cartographic literacy and map skepticism to educate the public. We must also ensure that we do not contribute to the infodemic through poor cartographic decisions, which can only be achieved by working ethical strategies into our workflows from the beginning of a project.

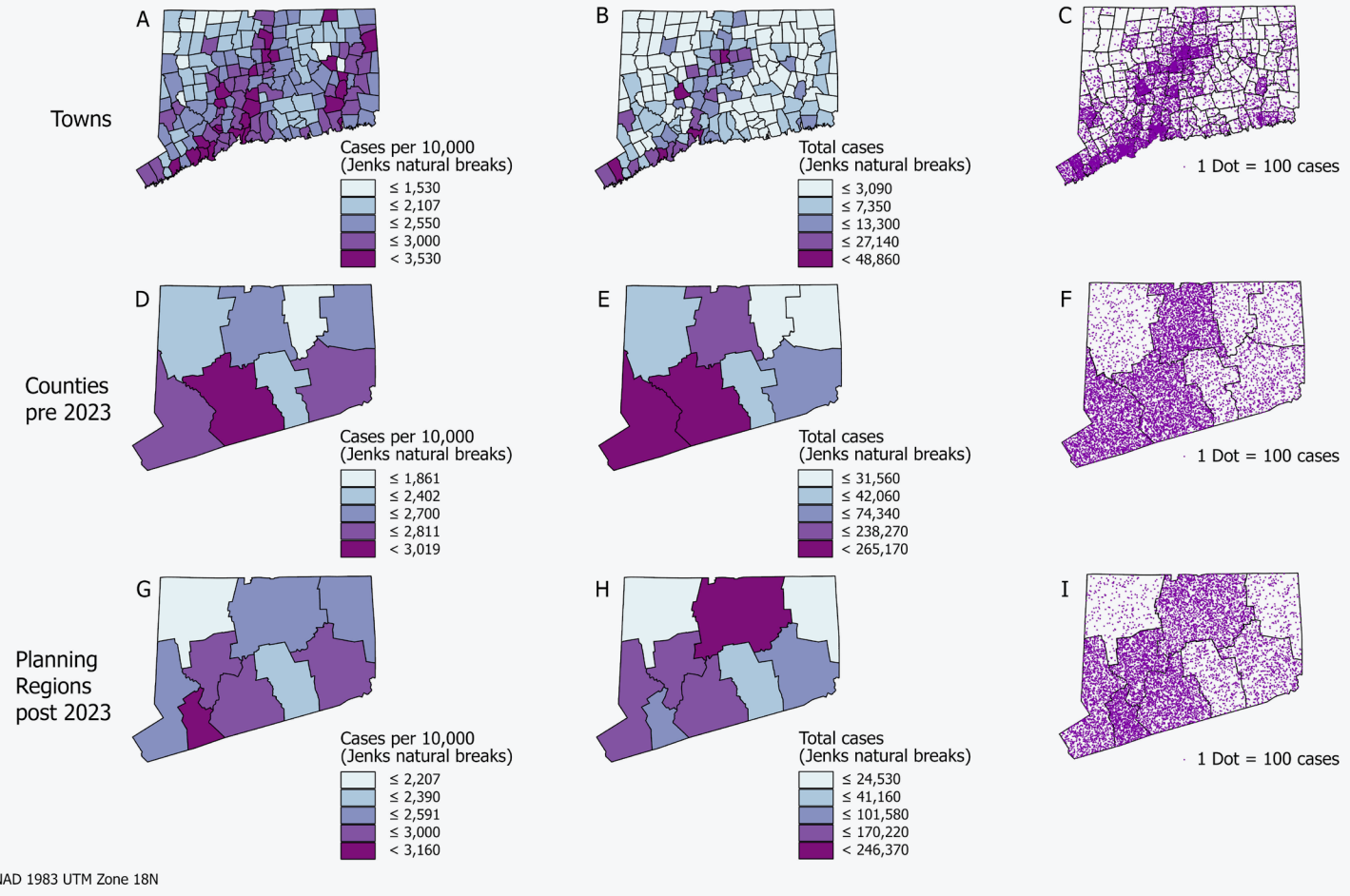

Figure 4. Prevalence of COVID-19 cases as of April 14, 2023, displayed with different symbolization methods and enumeration units.

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