Graphical Representations of Mortality Data With Confidence Intervals

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Mortality data are the most complete, standardized, and easily available—if not the only—data set for the epidemiological assessment of the health problems of a state or a county. Specific health problems of a state can be identified by comparing the cause-specific mortality rate of the state with a benchmark, such as the average mortality rate of the United States or of a state with similar geographic or sociodemographic characteristics. With the help of data visualization tools, stakeholders in health policy decision making can easily customize the required information.[1,2]

The use of a sequential color scheme (color ramp) to differentiate mortality rates between states in a choropleth map is common. However, this approach might result in the misinterpretation of differences in mortality rates between states. Two states with different color shades might not actually have a significant difference in mortality rates. The mortality rates estimated for a state with a small population would be less stable and have higher 95% confidence intervals (CIs). Studies have suggested calculating 95% CIs when comparing the mortality rates of states or counties for assessing needs or ranking.[3,4] Therefore, we used Tableau, a widely used self-service business intelligence software, to create a data visualization dashboard of US states' coronary heart disease mortality rates with 95% CIs (https://public.tableau.com/profile/robert.lu#!/vizhome/USACHDJun32016/Dashboard).

Software and Methods

One of the strengths of Tableau is that it can display multiple windows on a dashboard, which can provide complementary information for decision making. We first created a choropleth map (Figure 1A, left upper map) with only 3 color schemes. Blue indicates that the mortality rate of a state is significantly lower than the US average mortality rate. Red indicates that the mortality rate of a state is significantly higher than the US average mortality rate. Yellow indicates that the mortality rate of a state does not significantly differ from the US average mortality rate. The 3-color choropleth map provides basic health needs assessment information, that is, whether the mortality rate of a state is higher or lower than the US average mortality rate.

Second, we added a bar chart of the mortality rate ratio with a line of 95% CI for each state by using the US mortality rate as a reference (Figure 1A, left lower chart) as a complement to visualize if the mortality rate of a state is significantly higher or lower than the average US mortality rate. For example, the mortality rate of North Dakota was lower than that of the United States, with a mortality rate ratio of 0.94 (Figure 1A, left lower chart). However, because of a low number of deaths, the 95% CI was high (from 0.87–1.00), including 1.00; therefore, the mortality rate of North Dakota was not significantly lower than the average US mortality rate.

Third, we created a choropleth map (right upper map in Figure 1A) having a sequential color scheme (color ramp) for users who intend to compare a particular state with another state with similar geographic and sociodemographic characteristics. For example, Minnesota with the lowest mortality rate had the darkest shade of blue color. By contrast, Oklahoma with the highest mortality rate had the darkest shade of red color.

Fourth, to avoid misinterpretation of mortality rate differences, we added a bar chart of the mortality rate with a line of 95% CI for each state (Figure 1A, right lower chart). For example, the mortality rate of Montana (109.2 per 100 000) was lower than that of North Dakota (116.8 per 100 000). However, because of a low number of deaths, the 95% CI of the mortality rate of Montana was high (from 100.8 to 117.6), which overlapped with the 95% CI of the mortality rate of North Dakota (from 106.6 to 127.0). Therefore, the mortality rate between Montana and North Dakota did not significantly differ. Furthermore, the users can highlight selected states (such as 6 New England states in Figure 2) for better visualization of comparisons.

Fifth, we created filter buttons (ie, sex, age, and years of data) in the right side of dashboard, which is a crucial function of Tableau, so that users can select the specific dimension of information they require. Figure 1B illustrates the maps and bar charts of selection of people aged 20 to 44 years in 2014. Because of low number of deaths in this age group, we noted longer line of 95% CI in each state, and only 14 states had mortality rates significantly lower than the average US mortality rate.

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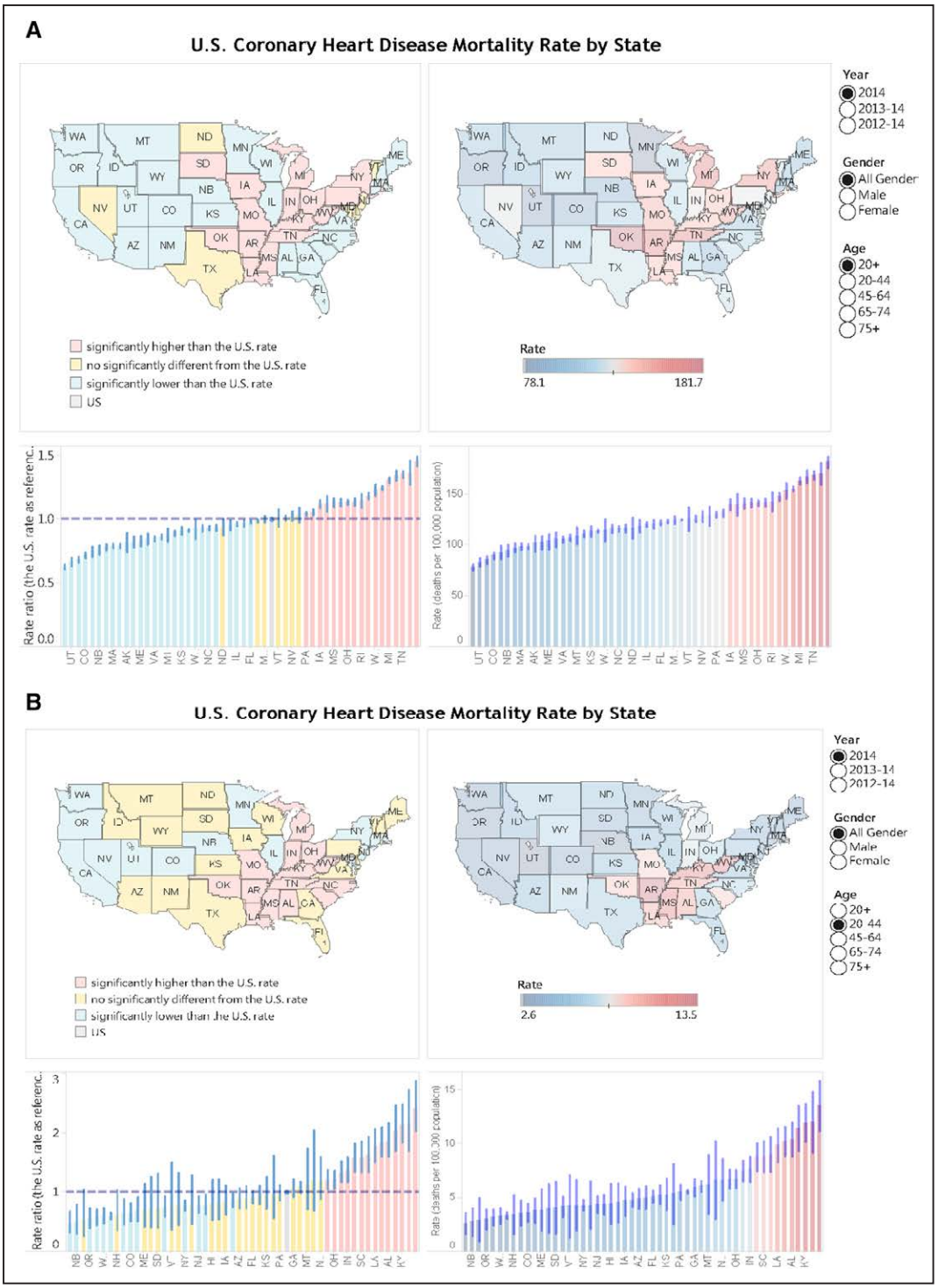

Figure 1. Dashboard of US coronary heart disease mortality rates and rate ratios with 95% confidence intervals by state for people aged ≥20 y (**A**) and 20 to 44 y (**B**), 2014.

Finally, because the number of deaths in some states and age groups was small, which may have resulted in unstable comparisons of mortality rates between states and age groups, we separately provided mortality rates based on 1-year data (2014), combined 2-year data (2013–2014), and combined 3-year data (2012–2014). The 95% CI of mortality rates based on the combined 3-year data for people aged 20 to 44 years was lower than those based on 1-year data. Number of states with mortality rates significantly lower than the average US mortality rate increased to 19 based on 3-year data, which was higher than those based on 1-year data (14 states).

In conclusion, the addition of a bar chart of mortality rates and rate ratios with 95% CI as a complement of a choropleth map with sequential color schemes can provide more precise information for appropriately interpreting

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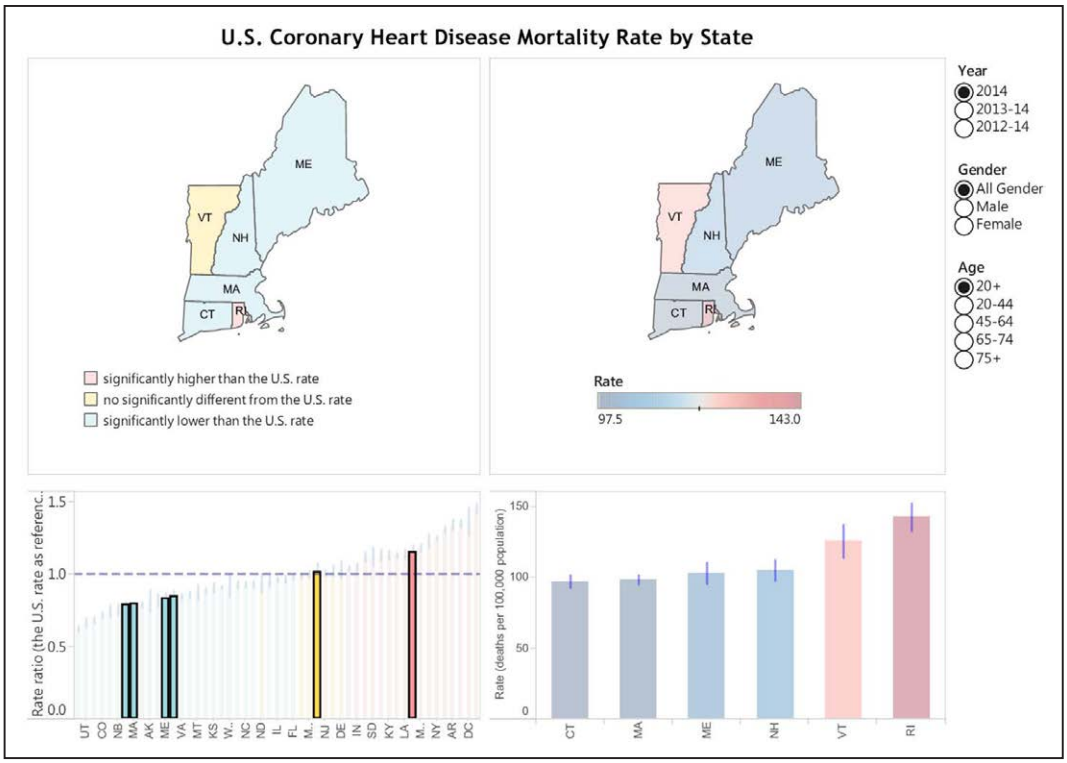

Figure 2. Dashboard of US coronary heart disease mortality rates and rate ratios with 95% confidence intervals of 6 New England states for people aged ≥20 y, 2014.

differences in mortality rates between states. Furthermore, presenting mortality rates according to data with different periods (combined 1-year data versus combined 3-year data) can provide more complete information for effective decision making.

However, cautions should be noted while undertaking pairwise comparisons. When users are increasing the number of pairwise comparisons, by chance, some will be statistically different mortality rate ratios. Users should include a correction to control for the overall false discovery rate. One limitation of presently designed dashboard was no voice function to speak out the mortality rate and 95% CI of a particular state when users hover their mouse over a particular state, which might be friendly to people with visual impairment.

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Disclosures

None.

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