Visualizing Polio Vaccination Trends in the United States: Status of the Nation

Richard Higgins, Guisu Li, Tahira Ahmad, Richard Ytzen

Abstract— Polio vaccination is one routine immunization for children. This article used the software Many Eyes to make the data analysis and visualization for the statistics of polio vaccination coverage for children 19-35 months of age in the United States. Information visualization displayed in various kinds of graphs(World Map, Line graph, Pie chart, Bar chart) could help the viewers grasp the data structures and patterns which are hidden in traditional data tables.

Index Terms— Vaccines, children, gender, race and social stature.

1 Introduction

Recent advances in geographical information and mapping technologies have created new opportunities for public health administrators to enhance planning, analysis, monitoring and management of health systems. Health mapping has evolved from Dr. John Snow's cholera death mapping in mid-nineteenth century to the latest Internet-based mapping where data have been shared across the Internet. Since much of the data used and generated by health and social service agencies has a spatial dimension, geographic information system (GIS) is particularly useful to health professionals and administrators in planning and day-to-day management.[1] By using graphical visualization tools we will show how easily users can gain a different perspective through visual exploration. Tables from the US Department of Health Services contain three kinds of data involving vaccines: vaccinations for selected diseases, by race, and residence; vaccination coverage by geographic division, state, and area; for Poliomyelitis and diphtheria and tetanus vaccinations as the 4:3:1:3 combined series because of the way vaccination doses are implemented [2]. In this paper we used Many Eyes to present this new perspective of data.

1.1 Many Eyes

Many Eyes [3] is a web base graphical application tool that is capable of taking tablature scientific data analysis and creating multidimensional visualizations. These visualizations can be depicted on bar charts, logarithmic graphs, World Map, treemaps, scatterplots, and histograms to name a few. In this study, this tool helped us analyze and visualize the data sets provided by the US Department and Human Services to discover patterns within the data. For those entrusted with the Nation's health, monitoring the health of America's children is an essential step for it aids in the formulation of appropriate health policies and prioritizing research programs. Vaccination is a very important preventive measure to protect children and adults from infectious diseases. The visualization of the vaccination coverage statistics could help public health professionals to assess their programs and evaluate how the Nation's resources should be directed to improve the population's health for its children.

Examination of emerging trends with visualizations from Many Eyes identified vaccination coverage distribution and risk factors that warrant more study and intervention. These include the variations of vaccination coverage for children 19–35 months of age by race and ethnicity, gender, poverty level and geographic location. Given the increasing diversity of the nation and the continuing changes in how the vaccinations are implemented, it is a challenging and critically important task to keep up with the trend of the data. The value of any visualization, including the ones contained in this paper, is the logical information that the viewer can conclude from the data being depicted visually.

1.2 Facts about Poliomyelitis, poliovirus and polio vaccination.

Poliomyelitis is an acute viral disease usually caused by a poliovirus and it could be developed into the minor illness or the major illness with a central nervous system involvement ranging from stiff neck, pleocytosis in spinal fluid, paralysis; to contraction in the muscle groups and permanent deformity [4]

Human is the only of the receptor polio virus. Virus dissemination is made by the fecal-oral and oral-oral routes. Feces could contaminate the water, milk, or food with the virus and houseflies could also transfer the poliovirus. Poor sanitation could ease the virus dissemination. [5]

The way to prevent poliomyelitis is the immunization with the polio vaccine.OPV was recommended for most children in the United States IPV in the past, and it is still used in many parts of the world. IPV is the recommended vaccine shot in the United States today. Chidren at the ages of 2 months, 6-18 months, 4 months, 4-6 years should receive the IPV and adults at adults are at higher risk of the infection should also receive the polio vaccination. [6]

In 1988, the World Health Organization (WHO) led an irradiation campaign with the goal of global polio eradication with the target date of 2000. Substantial progress has been made and now seventy of the children in the world live in a polio-free country. [7] In the United States, the last case of wild disease of paralytic poliomyelitis occurred in 1979. [8] But there are challenges in polio control. Vaccine-derived polioviruses (cVDPVs) could develop in areas of low vaccination coverage[7] . And there is an outbreak risk in " the presence of under vaccinated children in urban areas and among groups who refuse vaccination, should importation of wild virus occur." [8]

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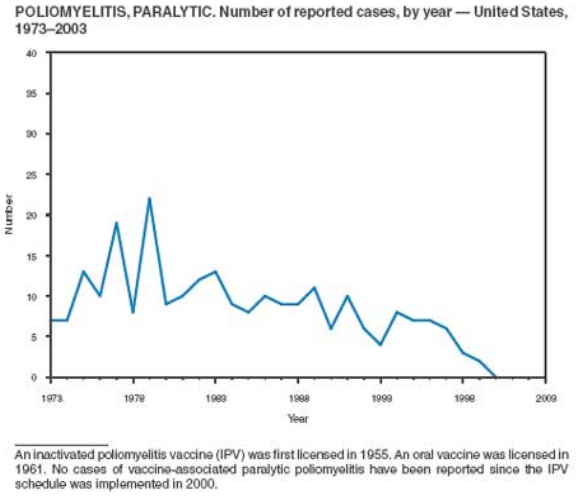

Fig. 1. Polio Reductions from 1973 to 2003 Thanks to the Polio vaccinations implanted by the US Department of Health. (Centers for Disease Control)

Literature identified many factors for immunization coverage used a national representative probability sample o children 19 to 35 months of age to assess the features of unvaccinated children and under-vaccinated children[9]. They found that "Unvaccinated children are clustered geographically", And unvaccinated children are distinctly different from under-vaccinated children in terms of child characteristics (races, gender), maternal characteristics (marriage, education), and household characteristics (income, Living in a MSA). [9].

The study of compared the immunization coverage of vulnerable children from health center and national rates[10]. They found that in the national immunization, significant race/ethnicity disparities and income disparities exist, and the radical disparities exist below poverty and also at or above poverty. They also found that for the health center immunization, the black children at the health center were significantly less like to be vaccinated for polio. Williams, et al.[11] (1996) studied the predictors of immunization coverage in Virginia children. They found one predictor is the socioeconomic status in that low-income children were the least likely to be adequately immunized. And the delay in receiving the first immunizations and the failure of simultaneous administration of vaccines, the first and second DPT and oral polio vaccine, were associated with inadequate immunization at the age of two[12]. Reviewed reasons for parents of children missed vaccination opportunities with regard to the latest immunizations, including parents' negative experiences of primary immunization, unintentionally missed vaccinations and dissatisfaction with the immunization service.

The visualization of polio vaccinations could help federal, state and local public health and clinical professionals to monitor vaccination coverage and find the patterns of coverage by race/ethnicity, socio-economics and graphical locations.

1.3 NIS Data Analysis Methodologies

We used the new statistical methodology for estimating vaccination coverage rates from National Immunization Survey (NIS) data, which was changed in 1998. The new methodology appropriately accounts for the survey's complex sampling design. [13]. The new methodology is described in Smith, P.J., Rao, J.N.K., Battaglia, M.P., Ezzati-Rice, T.M., Daniels, D., Khare, M. (2001). Compensating for provider nonresponsive using response propensities to form adjustment cells: the National Immunization Survey. National Center for Health Statistics. Vital Statistics 2(133). [14]

2 METHODOLOGY

We used Many Eyes to generate visualizations of Polio vaccination coverage using bar charts, pie chart, World Map, and logarithmic graphs.

3 RESULTS

3.1 World Map

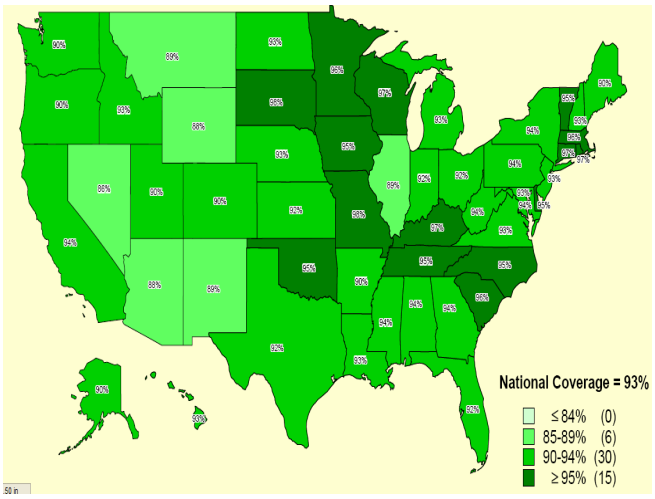

Fig. 2. Percentage of children 19-35 moths of age receiving three or more does of Polio Vaccine. (Centers for Disease Control)

The above visualization in figure 2, created using the tool Many Eyes, is a World Map which is fast at a glance image to convey state by state the percentage of children vaccinated for Polio in 2006.The darker shades of green indicating a higher percentage of kids vaccinated

This graph shows the percentage of children 19-35 months of age that receiving three or more does of Polio Vaccine in 2006. The six lightest green colors show the six that's having the lowest percent of polio vaccination coverage. Smith, Chu, & Barker found that "Unvaccinated children are clustered geographically".[9] From the graph, we found similar patterns. This graph could help the viewers to identify the states with similar and dissimilar vaccine coverage.

3.2 Line Graph

The vaccines represented in the figure 3 is the 4:3:1:3 combined series. It consists of 4 or more doses of diphtheria and tetanus toxoids and pertussis vaccine (DTP), diphtheria and tetanus toxoids (DT), or diphtheria and tetanus toxoids and a cellular pertussis vaccine (DTaP). 3 or more doses of any poliovirus vaccine, 1 or more doses of a measles-containing vaccine (MCV), and 3 or more doses of Haemophilus influenza type b vaccine (Hib). [2]

This line graph visualizes the continuous changes of the 4:3:1:3 vaccinations by states from 1998-2005. Each colored trace represents a state fluctuating vaccination program over seven-year period for a series of vaccines including Poliovirus

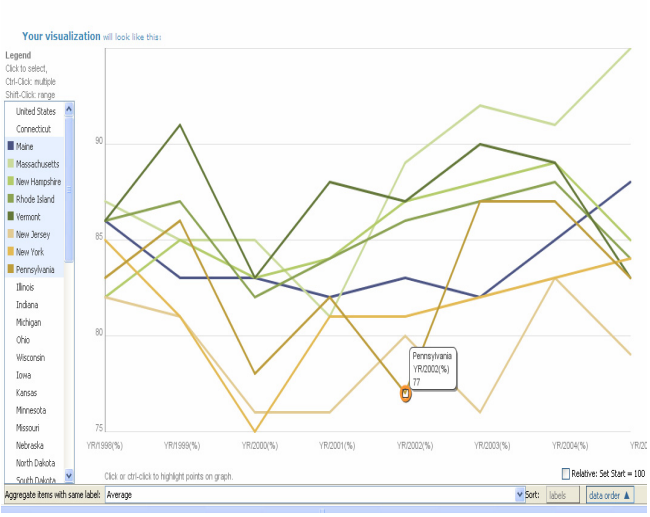

Fig. 3. Vaccines by state using 4:3:1:3 series 1998 – 2005. (Centers for Disease Control)

3.3 Pie Chart

The figure 4 is a pie chart using Many Eyes. The Pie chart shows the proportions of polio vaccination for children 19–35 months of age for all races, United States, selected years 1995–2005. Each slice is represented by a different color. A click of a slice could highlight it. We can see that the year 1995 had the lowest polio vaccination in children of 19–35 months old for all races. The year from 2003 to 2005 had the highest polio vaccinations. We also could select different data series in the slice size tool box, such as white children for the year 1995 to 2005. This chart shows that the polio vaccinations improved after the year 1995, but were reduced a little bit from 1999 to 2001, and improved again to the highest rate from 2003-2005.

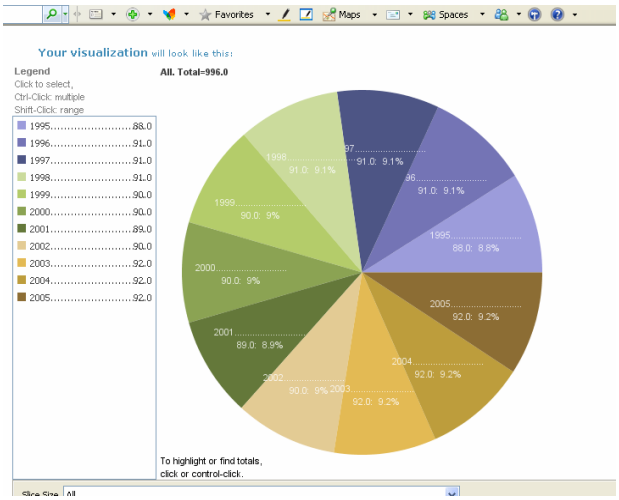

Fig. 4. Polio Vaccinations of children 19-35 months of age for all races in US 1995-2005 (Centers for Disease Control)

3.4 Bar Chart

The figure 5 is a bar chart we made from Many Eyes. The yellow bar is the percent of vaccinations of children 19–35 months of age that are below poverty level. The coffee bar is the percent of vaccinations of children 19–35 months of age that are at or above poverty level. The height of a bar corresponds to its value of a data series. A click of a bar in the graph could give the extract values and other information of the data series the bar represented. We could also

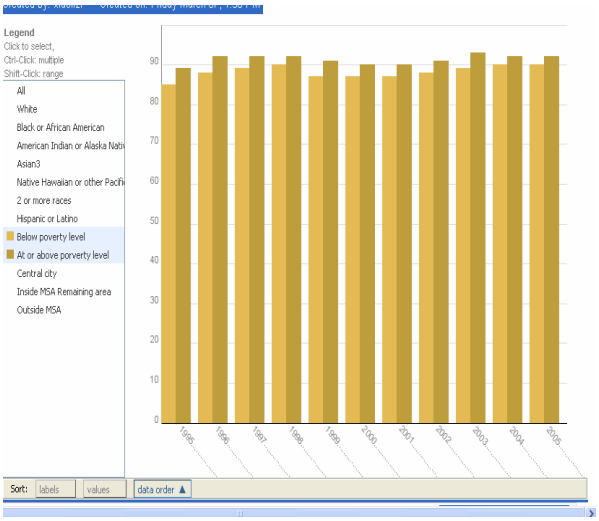

Fig. 5. Polio Vaccinations for Children 19-35 months of age by poverty level in the US 1995-2005 (Centers for Disease Control)

select different or multiple data series in the legend section to visualize them.

We can see that the yellow bars are a little shorter than the coffee bars for every year from the year 1995 to the year 2005. It visualizes the information that the disparity of polio immunization coverage exists between the children 19-35 months below poverty and at or above poverty level, as demonstrated in the literatures.[9],[10],[11]

4 Analysis

Many Eyes is human visual intelligence software aimed to find and visualizes the patterns from the data analysis. The data formats accepted by Many Eyes are a standard data table format with a header row. The only exception is that the tag cloud visualization for the data of free text.[3] Chi made taxonomies of information visualization techniques using the Data State Reference Model. [15]According to Chi's taxonomy, in our study, the United States Map (figure 2) is a geographical-based information visualization. The original data set contains statistics of vaccination coverage linked to geographical regions, which in the case is every state in the US. Many Eyes understands each state name as location data that can be visualized as a geographical map.

The bar chart (figure 5) in our study is a form of 2D visualization. The original data set is a numerical table number that contains percentages of vaccination coverage. Many Eyes converts each percentage into bars that can be visualized on a plot graph. Our visualizations result in offering the viewers the spatial information to the level of individual occurrence, as well as a predictive modeling.

Many eyes also allowed us to denote the intensity of Polio making it possible to keep track of affected geographical locations. The tables and charts explain what the graphic visualizations depict. Hopefully, this information will allow the viewer to easily understand and visualize the problems in relation to the visualization tool .Like most visualization tools, Many Eyes permits a dynamic link between databases and maps so that data updates are automatically reflected on the maps.

5 Evaluation of Many Eyes

The visualizations made by the tool Many Eyes are very useful. The US Map that was generated provides an overview and comparison among values of the variables from our data set This visualization utilizes a depth of colors to distinguish between values, and it also presents information about the relatedness of the data objects. For example, the states displayed in same color indicated

similar vaccination coverage, and such patterns would not been easily recognized by reading the original text tables.

The bar chart and pie chart created by Many Eyes are also useful to identify patterns in the data. For example, the variables of vaccination coverage in the bar chart could be arranged according to their values, which show the patterns of the sizes of vaccination coverage of the data set. In addition, a user could manipulate the tool to select the variables in which they are interested, or zoom in to see the details of a variable.

The visualizations made by the tool of Many Eyes are also very user-friendly. The interface is simple and the functions are easy to learn. Many Eyes has a very useful and simplified classification of options which serves as a great guide to show users what to try out to answer specific questions. The user-friendly usage of Many Eyes applies to all of their visualization types, which is more than a dozen. Some of the easy to use visualization types include interactive maps of the world and the United States, standard line graphs, stacked line graphs, and line graphs for categories that can be hierarchical, bar charts, block histograms, bubble charts, scatterplots, network diagrams, pie charts, treemaps and change treemaps.

All of Many Eyes' visualizations are interactive, allowing the user to query exact numbers, zoom in and out, and drill down further information. This feature is especially useful in the case of maps and treemaps. To help aid in the collaborative and social goal that Many Eyes was trying to achieve, the ability to create live snapshots for comments is also an excellent feature.

However, not all of the aspects of Many Eyes are positive. One problem that has been discovered is that on multiple occasions, users have had issues with their Many Eyes sessions. These users have articulated that Many Eyes seems to crash and produce error messages about how something might be non-operational or the site will not make it beyond the user agreement page. On one occasion a user could not see the data format and styles page at all. The session was working fine in the beginning because the format and styles pages loaded, but that was the only time it was usable. The user was unable to navigate back to that particular page during the session. It has been reported that this happens with other pages on the Many Eyes site as well while trying to access them where the browser would simply time out.

The only reasonable possibility for this anomaly one can think of is that maybe something went wrong when the registration was processed - maybe a new registration form should have been process for the team having these issues with Many Eyes. It is quite possible the user not to have been logged in. This brings up the usability issue if a user cannot tell if they are logged into a site or not.

One major drawback of Many Eyes is that it lacks a way to combine data from different data sets into one visualization. Many Eyes has a function that creates a very nice and compact thumbnail, but does not allow the user to embed or export a larger snapshot of the visualization directly. Many Eyes provides a link to a generated visualization, but that link simply points to the visualization, and does not take parameters or interactions into account. Any modifications that were done to the visualization are not captured in the link data.

Another disadvantage of Many Eyes is that, the user can not mix and match two or more different data sets. In addition, the ability to produce a visualization using two different graph types is not possible either. A feature with the ability to combine data sets or graph types would be useful to display rates of change, and not just absolute values. Additionally, Many Eyes does not seem to recognize dates, but can deal with hierarchical categories and graphs.

Lastly, Many Eyes is relying on the social and collaborative aspect of the Internet to create a new kind of data analysis. However, the site and registration process needs to foster and encourage the use of Many Eyes to as large of an audience as possible. Currently, the registration process is a hindrance to that goal. Any visitor to the site can view the visualizations and data sets, and create new visualizations from the existing data sets, but registration is what unlocks the social aspects of the site. Registering allows the users to rate the data sets and visualizations, which will allow the better visualizations and data to be recognized. In addition, registration will allow a user to upload data to add more to what is already saved. Lastly, registration will allow users to

create and participate in topic hubs, select specific items to watch, and see comments that others have written to you.

The last problem with Many Eyes lies within the registration process itself. When a user first navigates to the site, there is no quick and easy link to register. Users do not want to search for a registration link. Not all users are going to know to click the "sign in" link to be taken to a page that has a link for registration. The main page would benefit from a link that would offer the user a visual cue to find the registration page such as "Don't have a login? Click here to register!" The next problematic aspect is that the registration is for an IBM ID, and not just an easy Many Eyes' registration. A user clicking to register loses the look and feel of the Many Eyes site and is presented with the standard IBM page layout. This would be a deterrent for a user who just wants to use Many Eyes and does not want to be bombarded with the information with a My IBM registration.

6 CONCLUSION

As tools similar to Many Eyes become more accepted by mainstream researchers as they take advantage of viewing tablature data sets as visualizations, making the most salient information instantly identifiable at a glance.

This paper has shown that almost anyone can see that any one of the charts or graphs observes and appreciates how quickly the assimilation of all the information provided about children, their poverty level, age and the year vaccinated is understood.

With the tools like Many Eyes the visual analytics help make sense of the data at a glance and differentiates the data at different levels of abstraction, from macroscopic to microscopic. With Many Eyes users can often learn things about the data by just observing those data trends in a table carefully, but as this paper has shown sometimes users can learn more by doing something visual and graphically to the data and noting what happens.

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