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Data Visualization

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Data visualization is the visual representation of abstracted information, including quantitative and qualitative data (Friendly & Denis, 2001). Technological advances in data collection and analysis, coupled with the Internet-enabled instant accessibility of seemingly unlimited information, have fostered interest in finding the most efficient means of presenting huge quantities of data (Keim, Mansmann, Schneidewind, & Ziegler, 2006). Neuroscience has confirmed that the adage "a picture is worth a thousand words" is, if anything, an understatement. Visual processing occupies a large portion of our brains, and presenting information in visual formats can bring about improvements in processing speed, comprehension, and memorability (Tory & Moller, 2004; Ware, 2012).

At times, it may appear that data visualization is a new approach to addressing the relatively recent problem of information overload. In truth, data visualization has long played a role in social research and action. One of the most popular historical data visualization stories is that of Florence Nightingale, who created a novel graphical representation called the polar area chart, or "rose diagram," to present data demonstrating that soldiers were far more likely to die from infections than in direct combat (Friendly, 2008). This graphic was used to advocate successfully for improved sanitary conditions in the treatment of soldiers.

Although data visualization is theoretically and historically separable from modern information technology, in practice, they are deeply linked. The increasing availability of overwhelming amounts of data has been paralleled by innovations in data visualization. This includes newer static representations of quantitative data, such as sparklines, bubble charts, heat maps, and tree maps (Lysy, 2013), and qualitative data, such as phrase nets, graphic recording, and sentiment analysis (Henderson & Segal, 2013). It also encompasses dynamic and interactive representations of data that rely on technology. This chapter will focus primarily on innovations in data visualization that are particularly relevant to community research. First, we will explore the use of data visualization in exploratory data analysis, evaluation, and dissemination. Then we will present a brief step-by-step guide to data visualization. Finally, we will describe a case study of the use of free and low-cost data visualization tools to share pertinent data with members of a statewide coalition dedicated to preventing child abuse and neglect (CAN) in Hawaii.

INTRODUCTION TO DATA VISUALIZATION

Exploratory Data Analysis

Data visualization can facilitate hypothesis formation (Ware, 2012) and is often employed in exploratory data analysis. Scatter plots, histograms, and other graphical representations of data provide immediately comprehensible information and can help the viewer identify patterns and anomalies more readily than raw numeric data can. In community research, the ability of data visualization to allow users without statistical experience to identify patterns and develop research questions is particularly relevant in participatory research contexts. Participatory action research (PAR) and similar participatory research approaches focus on the inclusion of community members as participants in various stages of the research process themselves, rather than as only the subjects of research (Fisher & Ball, 2003; Nelson, Ochaka, Griffin, & Lord, 1998; Wallerstein & Duran, 2006).

Citizen science is another term that refers to instances where community members are involved in research (Bonney et al., 2009). It is a relatively new term that is used more commonly in the physical sciences and is exhibiting growing popularity. In fields such as ecology and ornithology, citizen science approaches have allowed community members to upload information about observations in their local environments. Technological advances, including advances in data visualization, have played a key role in the growth of citizen science, as they allow community members to then view data sets to which they contribute. Greg Newman, a citizen science expert who develops and evaluates online educational decision support systems utilized by citizen-based conservation organizations, noted the following:

> The role of data visualization is complex and involves science communication, making complex data more easy to understand, improving volunteer retention through engendering increased excitement among volunteers for their work, and ensuring that results are communicated back to volunteer data contributors. (personal communication, August 4, 2014)

Data analysis has long presented a challenge to participatory researchers because community participants do not always possess the specialized knowledge or technical resources necessary to participate in this crucial aspect of research (Wallerstein & Duran, 2006). As it makes complex data easier to understand, data visualization can improve the ability of lay researchers to participate in data analysis, particularly exploratory data analysis. By making raw data easily accessible, it can enable community members, who possess in-depth contextual knowledge about community history and conditions, to inform the development of research questions that researchers may never think of on their own. Researchers with knowledge in research design and advanced analytical techniques can then apply these skills in new studies based on data-driven community-informed research questions. They may then use data visualizations in their final products to communicate results back to community members.

Successful participatory or transdisciplinary action research requires collaboration over time between researchers and community members or leaders (Stokols, 2006). The integration of online communication platforms with data visualization technologies can facilitate open communication about data and remove some of the barriers to effective collaboration. Online communication in these platforms may benefit from disinhibition, by disrupting power dynamics or cultural barriers and opening communication (Chester & Gwynne, 1998). DeSouza and Smith (2014) suggested that the promotion of citizen science and the use of virtual experimentation platforms can help those studying social issues to take full advantage of the recent significant advancements that have been made in data collection and analysis.

Evaluation and Decision Making

Data visualizations that include a dynamic component provide opportunities for ongoing monitoring and data-driven decision making. The business sector has in some ways led the way in the use of these technologies to make strategic decisions, although its use is increasing in other fields, such as education (Dickson, 2005). It can be an invaluable tool in the evaluation of community programs, and in fact the American Evaluation Association released a two-part issue of *New Directions for Evaluation* dedicated entirely to data visualization (Azzam & Evergreen, 2013).

In their simplest forms, dynamic visualizations can be charts made in Excel that are connected to data in a spreadsheet so that they automatically update as data are modified or new data are added. In their most complex forms, data visualizations can be connected to multiple data sources and even XML or HTML data to pull in and display real-time data updated from the Web. Although dynamic visualizations include any chart or graph that is automatically updated as new data are added, their function is commonly applied to the use of information dashboards.

Information dashboards are customized visual displays of quantitative information that have been arranged to fit on a single computer screen for quick, real-time monitoring of program-specific objectives (Few, 2006). Dynamic dashboards were originally developed and used in business settings so that organizations could quickly assess and respond to changes. Given the need of many community organizations to demonstrate accountability, compliance, and programmatic results,

dashboards could be an important tool when utilized by community researchers. Just like the dashboard in one's car, an information dashboard allows one to quickly glance and monitor the most important information about one's performance and progress toward objectives. If the fuel gauge in one's car is dipping below empty, then one is likely to take action toward locating a gas station to refuel. Similarly in community practice, the application of these real-time, information monitoring dashboards can help programs make evidence-based decisions to take corrective actions if they are not meeting their progress goals (Smith, 2013). This is compatible with an empowerment evaluation approach (Fetterman & Wandersman, 2005) because program leaders and staff may obtain ongoing information about their programs without an intermediary, once the dashboard is created and a refresh protocol is established.

Dynamic information dashboards are typically used with specific strategic, analytical, or operational purposes. Summary charts and data can provide management with information for strategic planning purposes. Dashboards with interactive capacities to drill down into the data can provide managers with analytical capabilities to evaluate and research programmatic data. Monitoring dashboards can provide dynamic feedback to programs in order to assess progress toward objectives, indicate if corrective action is needed, and provide operational functions including formative evaluation, program adherence, and quality assurance (Smith, 2013). When utilized to their full effect, dynamic visualizations and information dashboards can offer programs efficient displays of important program data, provide effective presentations of information, and empower programs with the capacity for real-time monitoring and data-based decisions for change and improvement.

For those with more modest visualization ambitions, there are ways to increase the ability to communicate visually even while sticking with that old reporting mainstay, Excel. Stephanie Evergreen and Ann Emery blog regularly about data visualization in program evaluation and have posted several tips for improving Excel charts. Together, they have created the Data Visualization Checklist (Emery & Evergreen, 2014) to help evaluators use basic design principles to transform cluttered generic graphs into streamlined intentional visual representations of data.

Dissemination

Data visualization is particularly important in communicating research results to a lay audience, including policymakers, organizational decision makers, and the general public. Visualizations can be shared via mainstream media or social media to promote public awareness. They can be used more strategically in communication with policymakers in order to promote evidence-based policies. The effective use of data visualization can transform research findings into persuasive messages that lead to individual or collective action.

One form of data visualization that has gained tremendous popularity is the infographic. Infographics present data in visual formats that are easy to understand and can be quickly consumed (Smiciklas, 2012). Editorial infographics are designed with the intention to tell a story, rather than to present unbiased information (Lankow, Ritchie, & Crooks, 2012). A well-designed infographic can provide a very compelling story; because of this, it can also be misused by media outlets to misinform the public. The ubiquity of infographics results from their efficiency in communicating data, their user friendliness, and the ease with which they can be used in multiple media formats: shared in social media, included in a newspaper or online article, or presented quickly on television in a news story.

The most common type of editorial infographic is a static and simplified image that combines a visual representation of quantitative data with limited text accompaniment. In contrast with data visualizations that are designed for a specific and invested audience (such as dashboards for businesses), infographics are often targeted toward a broad audience that may have no initial interest in the graphic's topic. Because an editorial infographic must entice a potentially unwilling viewer to look at it, as well as tell a story and possibly persuade the viewer to take action, there is an especially large burden for this type of visualization to be visually compelling. Graphic designers may play a larger role in the creation of infographics than other types of visualizations. However, there are tools that allow users without graphic design expertise to create infographics fairly easily.

Infographics are not limited to digital images. They can be shared in the form of animations, interactive Web graphics, or even public data displays. Claes and Moere (2013), contending that our

visual landscape is cluttered with advertisements and other unwanted visual imagery, described an urban intervention they called Street Infographics in which they created simple infographics about resident characteristics and affixed them to four street signs. The graphics were strategically designed to match the street signs in color and size, so that they looked like an extension of the signs rather than a disruption. The graphics presented very simple information regarding the proportion of each street's residents in three categories: permanent resident, student, or international. They briefly interviewed 35 passersby who had stopped to look at the display and found that, although the passersby had different levels of recall in terms of detail, they all understood the infographics correctly. Many reflected on the meaning of the information, including one community member who reported modifying a previously held belief after reading the display.

Infographics represent only one method of using data visualization to disseminate information. There are more ways of using data visualization to disseminate information than could possibly be included in this chapter, including burgeoning methods such as the use of video games or mobile apps (Newman et al., 2012). In a sense, dissemination is always a goal of data visualization. In citizen science, ongoing or final results of research projects are disseminated to community researchers. In program evaluation, information is disseminated to program leaders or staff. The audience may be broad or narrow, and the amount of information included may be large or small, but in all instances, the strength of data visualizations is its ability to convey information in a way that is suited to the way the human brain operates.

CREATING A DATA VISUALIZATION: A STEP-BY-STEP GUIDE

The following steps were adapted from Smith's (2013) guide to creating dynamic dashboards. The order and the degree of time spent in each step may differ depending on the type and complexity of the visualization. However, the steps for creating an effective data visualization are ultimately the same, whether it is a complex interactive visualization, an artistic infographic, or a simple but well-designed Excel chart.

Step 1: Identify Your Purpose and Target Audience

This is necessarily your first step, because your purpose and target audience will determine which type of visualization you will create. It may be helpful to formulate a statement describing your specific purpose. For example, you may have the following goal: "To convince state policymakers that additional funding is necessary for women's health in my county."

Step 2: Determine the Specific Focus Area for the Visualization

In the earlier example, the general topic of the visualization has been identified: "women's health." However, this is a very broad topic, and any attempt to visualize it may result in something that is too generic to be effective. In this example, the visualization may focus specifically on a particular health problem that is more prevalent in your county.

Step 3: Locate, Vet, and Manipulate Data

This step may actually consist of many substeps, particularly if you are creating a sophisticated visualization that combines data from multiple sources. However, in the simplest case (as with a very simplified infographic), it may consist of finding a single reliable data point. In some cases, as with dynamic dashboards, the actual data may not be available when you are designing and building the visualization. In these cases, you still need to know what kind of information will be presented, and it is recommended that you obtain a dummy data set before you actually build the dashboard. In all cases, the source(s) of data used in the visualization should be included somewhere on the visualization itself or in accompanying documentation. Particularly for visualizations that are aimed at educating or persuading a broad audience, inclusion of this information is necessary to ensure that the visualization is viewed by audience members as trustworthy.

Step 4: Design

The next step is to begin designing the visualization. You may consider several different options for presenting the same information. This stage may consist of a quick pen-and-paper sketch or, in the case of more complex technical visualizations, a graphic mockup. When you are designing and building your visualization, you should be mindful

of basic design principles. Upon creating a draft or prototype, it is recommended that you look explicitly for design problems or for opportunities to add or subtract an element.

There are many recommendations for best practices in data visualization. One of the most universal design rules is to simplify visualizations to the extent possible (Evergreen, 2013; Few, 2009; Tufte, 1983, 1990). This includes the removal of any visual clutter, such as extraneous gridlines and tick marks, unnecessary color gradations or three-dimensionality, and redundant information. It also means looking for opportunities to reduce the amount of work that people have to do in order to make sense of the data, such as directly labeling chart elements rather than having a legend, using line charts to describe change over time, and using bar charts rather than pie charts to compare quantities in recognition of the fact that, despite the loveliness of Florence Nightingale's rose diagram, people are generally not very good at visually determining the area of a circle.

Tufte (1983) was adamant about maximizing what he called the "data-ink ratio," and what Few (2006) renamed the "data-pixel ratio," such that visualizations consist only of what is necessary to make the data intelligible. However, there are some who disagree with this hard-line approach, saying that there are cases where what Tufte would call "visual noise" may actually facilitate cognitive processing. For example, the use of visual metaphor in infographics is extremely popular and often recommended (Lankow et al., 2012). Visual metaphors make connections between new information and existing knowledge. Computers are replete with visual metaphors in the form of icons, from the trash or recycling bin where you drag items that are no longer needed, to the folders where you store information, to the now quaint floppy disk you click on when you want to save a file. We take these images for granted, but they are actually visual metaphors that were crucial in helping early users of graphical interfaces understand how to interact with machines. Visual metaphors, when used appropriately, can improve comprehension and serve as mnemonic aids facilitating later recall (Eppler, 2006), although they also have the potential to be distracting or misleading. The use of visual imagery can also make information more emotionally impactful, which can facilitate later recall. The affective impact of visual imagery may be particularly important when the goal of the visualization is to persuade the viewer rather than to share unbiased information (Huddy & Gunnthorsdottir, 2000). The design strategy should be compatible with the goal of the visualization and tailored to the target audience. Even when the visualization incorporates what Tufte called "non-data ink," attention to simplicity can ensure that irrelevant visual features do not distract from the visualization's primary message or function.

Step 6: Build

Particularly in the case of complex interactive and/or dynamic visualizations, there may be a clear separation between the design and build stage. This latter stage may involve more complex technical linking of data sets or inclusion of interactive components. However, the boundary between designing and building, even in such instances, is fluid. Both may be subsumed under a step called "Experiment." During the build phase, problems with the initial design may be revealed. An ongoing process of reflection and refinement is necessary in order to create an effective visualization.

Step 7: If Possible, Get Feedback and Iterate

Ideally, before the visualization is finalized, you will have an opportunity to share it with other potential audience members and to gather direct feedback. This process may be formal and include structured questions, or it may be open ended and conversational. Regardless of the approach, having at least some direct feedback from people who have not been involved in the design process and who resemble your target audience can be extraordinarily helpful in ensuring that the visualization meets its main objectives.

Step 8: Finalize and Share

At some point, the refinement must end and the visualization must be finalized. When this occurs, it is important to have a plan for ensuring that it actually reaches your target audience. For simple static visualizations, this may consist of inclusion in a report or Web site, or a broader outreach effort that includes plans for sharing on social media or targeting specific news outlets. For more complex interactive visualizations, this may also include the creation of written or video instructions to

ensure that people are able to use the visualization effectively.

When creating dynamic visualizations, such as dynamic dashboards, this must also consist of determining the refresh rate and creating a process to ensure that data are refreshed over time (Smith, 2013).The refresh rate indicates how often the dashboard will be updated with program data, and the protocol includes guidelines for data entry, steps for importing and managing the data, and procedures for reporting. Once the dashboard is constructed and populated with data, the dashboard can be published through interval reporting or by providing online access to key stakeholders. Once a dashboard is operational, some time and care should be taken to evaluate the utilization and effectiveness of the dashboard toward monitoring program objectives and meeting its intended utilization needs.

CASE STUDY

Background

This case study describes the use of data visualization with a coalition dedicated to preventing child abuse and neglect. Child abuse and neglect (CAN) is a pervasive problem that can have long-term consequences on mental and physical health (Norman et al., 2012; Shin & Miller, 2012). Programs and policies dedicated to preventing CAN and promoting child well-being are investments in the long-term health and well-being of adults. To achieve and sustain programmatic and policy changes that can support the prevention of child abuse and neglect, coordinated action at multiple levels is required (Daro & Dodge, 2009).

The Hawaii Children's Trust Fund (HCTF) Coalition is a statewide coalition of individuals and organizations dedicated to CAN prevention. The first author of this chapter began working with HCTF on a team evaluating the effectiveness of a public awareness campaign designed to promote knowledge of protective factors that have been linked to reductions in CAN rates (Cardazone, Sy, Chik, & Corlew, 2014). After completing this evaluation project, she collaborated with HCTF again in an effort to increase Coalition members' ability to use data. One element of this effort was the creation of several "data products," including a set of interactive data visualizations and an infographic.

The decision to create these products emerged after members were surveyed and the results indicated that most of the respondents believed in the importance of data-informed decision making, but that many perceived barriers to using data effectively. Based on the responses to open-ended questions regarding data usage and needs, the first author created a Knowledge Translation Survey. This survey included three sections: rankings of desired data product, rankings of desired data formats, and a checklist of data sources that were currently in use or that participants wished to use.

Coalition members indicated that they were most interested in obtaining data products that focused on effective CAN prevention programming and Hawaii CAN statistics and that they preferred to receive data in the form of data visualizations or infographics. Next, we describe the formation of two data products that were created to respond directly to this need. The first is an interactive data visualization of Hawaii CAN rates. The second is an infographic based on the results of a systematic review of home visiting programs, focusing particularly on their applicability to the field of CAN prevention.

Product 1: Interactive Data Visualizations of Hawaii CAN Rates

The participants indicated that they most often used data from the Hawaii State Department of Health (DOH) and Department of Human Services (DHS). However, some members noted a desire to have data from this source shared in a more easily accessible manner. The first interactive data visualizations were created with this in mind, as a way to introduce Coalition members to a new way to explore data from a familiar source.

Interactive data visualizations were created using Tableau Public 8.0 (www.tableausoftware.com/public), a free version of the proprietary Tableau data visualization software that is meant for use with public data. Data were transformed in order to conform to the Tableau guidelines, which require that each variable be represented only once per row and that all totals and subtotals be removed.

Although initially several different visualizations were created using various data sources, this approach changed after the first author collected initial feedback on early products. After this, efforts were focused on creating a single interactive dashboard based on a frequently used and relevant source

of data, the substantiated CAN rates by region available from the DHS's annual Child Abuse and Neglect Reports. In the dashboard, several views were used in order to highlight different aspects (e.g., showing differences in average CAN rates by region vs. showing changes in CAN rates over time).

Because DHS data on CAN prevalence are presented in counts and not normed according to the population, demographic data were used in order to calculate the rates of CAN in different geographic regions. Additionally, because the regions used in these reports are judicial districts rather than census divisions, additional calculations had to be made using an equivalency guide for determining the relationship between judicial districts and census county subdivisions.

The data were presented in four formats: (a) bar graphs allowing easy at-a-glance comparisons of CAN rates in different regions; (b) line graphs depicting changes in CAN rates for each region over time; (c) a map of the Hawaiian islands with CAN rates by county; and (d) a tree map displaying nested rectangles representing each district, with the hue of each rectangle based on county, the shade based on CAN rate, and the size proportioned according to child population. The first three formats were also presented on a dashboard, which can be filtered by county or year.

For all products, efforts were made to adhere to principles of effective data visualization, such as the strategic use of color to convey meaningful information and the use of small multiples of similar graphics to allow for fast apprehension of large quantities of information (Tufte, 1983, 1990). Earlier versions of the visualizations in Figure 29.1 were improved in several ways based on reflection on design principles and feedback from stakeholders.

The map of Hawaii in the upper left corner of Figure 29.1 underwent the most substantial changes. Originally, it was a map with each of the four counties in different shades of the same color corresponding to their CAN rates. This shading

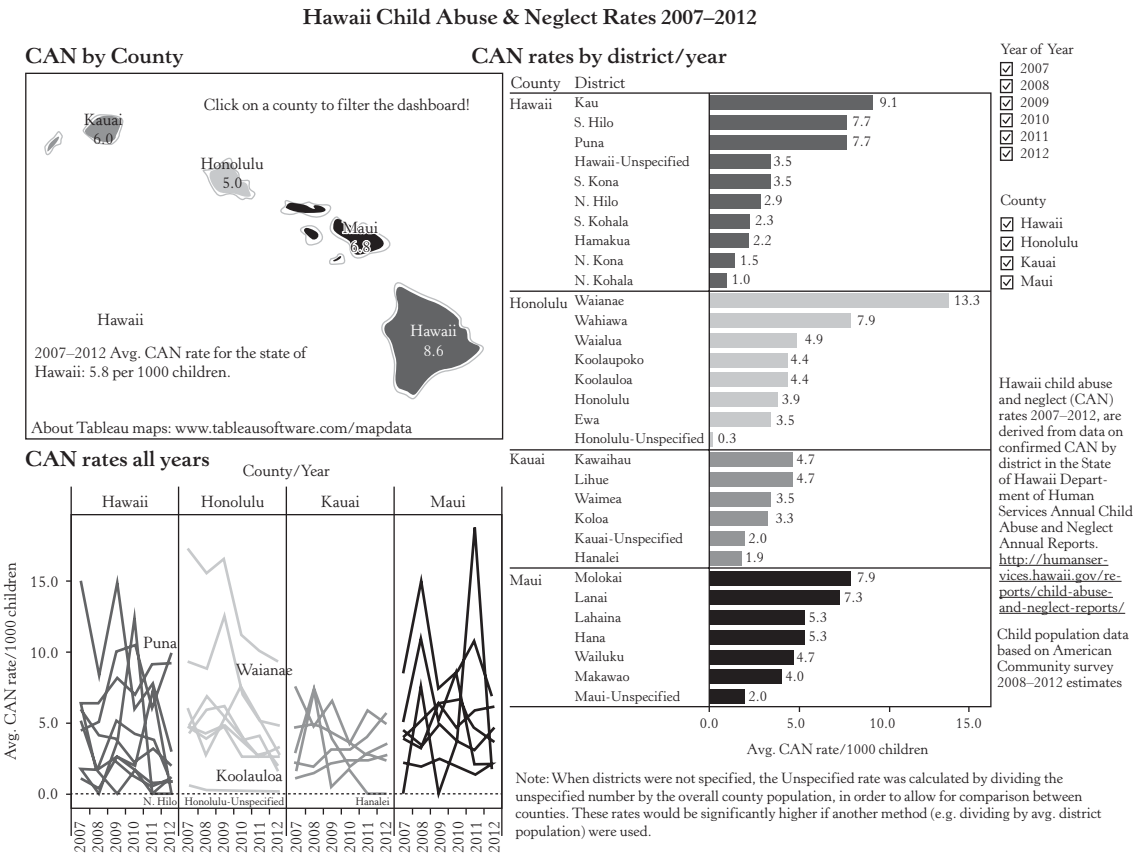

FIGURE 29.1: Hawaii child abuse and neglect rates for 2007–2012. Dashboard includes multiple charts, all of which can be filtered by year or county. Each chart is also visible in a full view via tabs.

did not provide a significant advantage in comprehensibility compared to a map without shading. Furthermore, the color scheme was not aligned with other visualizations in the dashboard. The map was therefore changed so that the color of each county followed the color scheme of the other visualizations. This provides a visual guide so that someone can quickly look at the map and contextualize the remaining images. This map was also made into an alternative interface for the interactive filter, so that, for example, one could click on the island of Kauai and the rest of the dashboard would be filtered so that only the results from Kauai are shown. The alternative interface for filtering by county through the use of checkboxes was kept, however, because it allows the user to more easily choose multiple counties to compare at once.

Perhaps most crucially, the overall Hawaii CAN rate, which had been entirely absent from the original design of this dashboard, was added in text in white space below the islands. This was in direct response to feedback from stakeholders, who thought it would help to contextualize the rates for each county and for individual districts.

Minor modifications were also made to the other visualizations. For the visualization in the lower left corner of Figure 29.1, the original design included data over time for all four counties in one image. This was extremely cacophonous and was changed to a small multiples format, where the same data for each county are presented side by side. Although the result is still visually busy, particularly in the dashboard view, it does allow some information to become instantly apparent, such as the fact that rates for Kauai districts are consistently low, while the district with the highest CAN rate in Honolulu has exhibited decreases over time. In the visualization on the right side of Figure 29.1, the original version had districts presented alphabetically within each county. This was changed so that districts are sorted according to CAN rate from highest to lowest. This is both visually cleaner and more immediately informative, as it will always list the district with the highest CAN rate first even if the results are filtered by year and the order changes.

Product 2: Infographic on Home Visiting

In response to the participants' stated desire for information regarding effective CAN prevention programs, an infographic was created based on information from the comprehensive Home Visiting Evidence of Effectiveness Review (HomVEE; Avellar, Paulsell, Sama-Miller, & Del Grosso, 2012). Although the HomVEE review included information about the effectiveness of select home visiting programs in a variety of outcomes, this infographic specifically highlighted programs with evidence of effectiveness in preventing child maltreatment. The infographic was designed for a lay reader, with a central theme guiding its development: Home visiting programs can be effective in helping to prevent child abuse and neglect. The goal of this infographic was to tell a story rather than to translate large quantities of data, and therefore much information was abbreviated or left out entirely in order to make an intelligible graphic.

The infographic was created using Piktochart (www.piktochart.com), a low-cost online tool that includes templates, icons, and other materials that facilitate infographic creation by people with limited graphic design expertise. There were some substantial limitations in the options for presenting information using this tool. However, this tool and similar Web-based tools can be extremely useful for those lacking access to a graphic designer or design software.

The infographic (see Fig. 29.2) has four sections. The first (top) section quickly describes home visiting programs for those who may be unfamiliar with them. The second section highlights the six programs that were identified by HomVEE as showing substantial evidence of effectiveness in preventing CAN. The third section describes the standards HomVEE used in determining effectiveness (e.g., rates of substantiated CAN, self-reports by parents using validated measures, emergency room visits and hospitalizations). The fourth section illustrates the other potential benefits of home visiting by showing the proportion of these six programs that also demonstrated positive outcomes in the following areas: child health, maternal health, child development and school readiness, and positive parenting practices.

The design of this infographic was not subject to the same level of refinement as the interactive data visualization (Product 1) and did not benefit from external feedback. Therefore, it probably contains more text and extraneous graphics than would be ideal. However, there was much refinement in conceptualizing the infographic. The author's original plan was to create an infographic that summarized

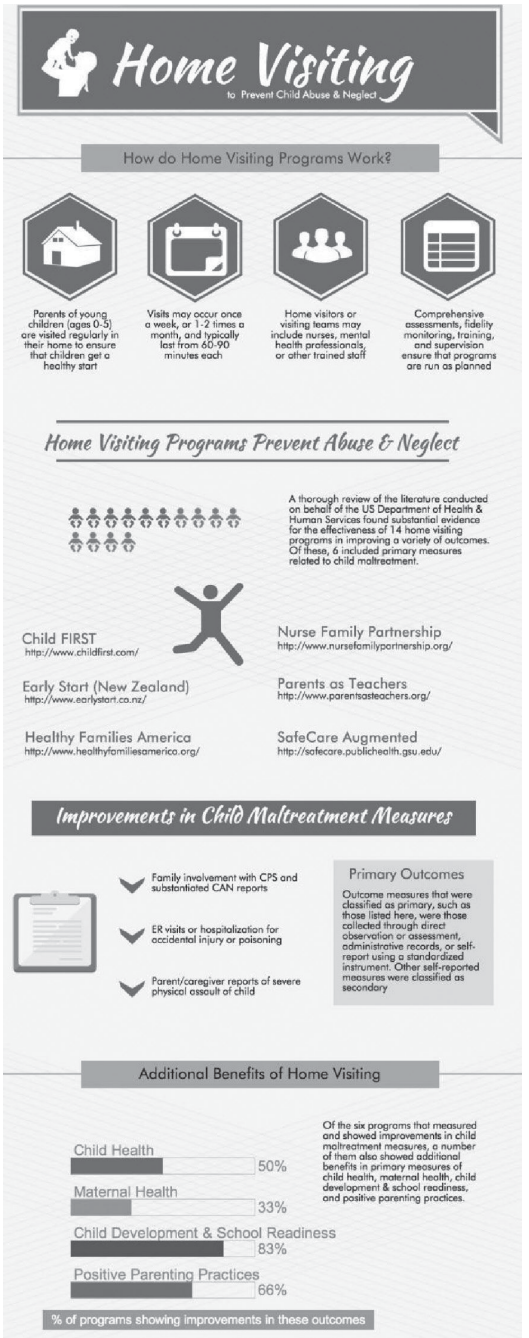

FIGURE 29.2: Infographic for home-visiting programs effective in preventing child maltreatment.

Data source: Avellar, S., Paulsell, D., Sama-Miller, E., & Del Grosso, P. (2013). Home Visiting Effectiveness Review: Executive Summary. Office of Planning, Research and Evaluation, Administration for Children and Families, US Department of Health and Human Services, Washington, DC.

a wide variety of literature on strategies to prevent child abuse. An early version of the infographic was completely different, and the author noted that it lacked the simplicity and narrative coherence that are necessary for infographics to be successful. There were also some inconsistencies in the literature regarding what CAN prevention strategies work under particular conditions. Accordingly, the subject of the infographic was altered to focus on one specific strategy (i.e., home visiting) that has repeatedly demonstrated success in CAN prevention. Instead of culling data from multiple sources, a single trustworthy source was used. The result is a more focused and, hopefully, more effective product.

CONCLUSION

Data visualization has become increasingly popular as people and organizations seek to cope with the astounding amount of information that is now available. For community researchers, data visualization has significant potential for bridging the divide between researchers and community members. Whether the goal is to facilitate participatory research, empower community-based organizations to monitor their program's progress, or share the results of research with a broad audience, thoughtful visualizations can make data more accessible and remove barriers to engagement. As technological advancements have increased the amount of information available, they have also spurred innovations in data visualization, such as the development of interactive visualizations and dynamic dashboards. However, even when developing simple graphics with rudimentary tools, attention to the principles of good design can improve the ability of researchers to make information intelligible to other researchers and to community members.

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