

Evidence-Based Decision Making Using Visual Analytics for a Local Food Bank

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ABSTRACT

Food insecurity is defined as an individual or household's inability or limited access to safe and nutritious food that every person in the household need for an active, healthy life. In this research, we apply visual analytics, the integration of data analytics and interactive visualization, to provide evidence-based decision making for a local food bank to better understand the people and communities in its service area and improve the reach and impact of the food bank. We have identified the indicators of the need, rates of usage, and other factors related to the general accessibility of the food bank and its programs. An interactive dashboard was developed to allow decision-makers of the food bank to combine their field knowledge with the computing power to make evidence-based informed decisions in complex hunger relief operations.

Keywords: Food insecurity, Visual analytics, Decision-making, Food bank

INTRODUCTION

Food insecurity is defined as an individual or household's inability or limited access to safe and nutritious food that every person in the household need for an active, healthy life (Campbell, 1991; Coleman-Jensen, et al., 2020). The United States Economic Research Service (ERS) reported that 13.7 million households (10.5% of US households) were food insecure at least sometime during the year and 4.1 percent of the household experienced very low food security defined as one or more times, the food intake of household members was reduced, and their eating patterns were disrupted (Coleman-Jensen, et al., 2020). Food insecurity can be attributed to poverty, underemployment, stagnant wages, and rising costs of living (Davis, et al., 2016).

In North Carolina, 1,417,440 people including 419,470 children are facing hunger (Feeding America, 2021). In other words, 1 in 7 North Carolinians and 1 in 5 children are facing hunger. The food insecurity rate for North Carolina is at 12.1% based on a recent study of three year average (2018-2020) conducted by United State Department of Agriculture (USDA), which ranks NC the 11th with food insecurity among the nation (USDA ERS, 2021).

Many households that face food insecurity are not eligible for deferral nutrition programs and rely on hunger relief organizations such as food banks. Feeding America is the largest hunger-relief organization in the United States and has a network of 200 food banks across America. Food banks are nonprofit organizations that aims to improve food insecurity by seeking

donated food from various sources (individual donors, supermarkets, etc.) and redirecting this food to individuals or households seeking charitable food assistance. A typical food bank has a network of branches that serve as hubs for food distribution. Each food bank branch works with local partner agencies to get the food directly to individuals that need food assistance within their service area. With the increased demands and the prevalence of the food insecurity, food banks often need to purchase food as well. The Covid-19 pandemic has caused the demand to increase and there is an urgency to meet the needs from the food insecure individuals and/or households. Food bank operations are very complex due to its inherent uncertainty in both supply and demand (Delpish, et al., 2018). Supply of the food bank comes from donations from manufacturers, grocers, and farmers and the amount and quality of the food items are not certain and can be affected by multiple factors. On the other hand, the needs from the food insecure individuals and/or the households drives the demand for the food bank and these needs are dependent on socioeconomic factors such as poverty and unemployment, and the sudden-onset disasters such as natural disasters (i.e., hurricanes) and slow-onset disasters such as pandemic (i.e., COVID-19). These disasters can cause disruptions in the community including economic losses to individuals and households which can aggravate the food insecurity.

There are seven feeding America affiliated food banks in North Carolina and one of them is Second Harvest Food Bank of Northwest North Carolina (SHFBNNC). SHFBNNC serves 18 counties in northwest NC. SHFBNNC has a network of nearly 470 partner programs and distributes over 43 million pounds of food to over 170,000 individuals across 18 counties every year. Each county and partner program have their unique assets, needs and challenges. The complexity of the food bank operations prompted SHFBNNC to seek understanding of the root causes of food insecurity in the service area and to maximize the reach and impact of the food bank and their network. In this research, we worked with SHFBNNC to utilize visual analytics (VA), an approach that combines data analytics with human factors (Desai, et al., 2017; Parks, et al., 2021) to provide evidence-based decision making support to food bank operations managers.

METHOD

In this research, we adopted human centered design (HCD) approach in the development of the interactive dashboards for the food bank. HCD focuses on the requirements of the potential user from the product's inception and checks at each step of the design phase with these users to ensure satisfaction with the final interface design. We started with analyzing the needs and requirements of SHFBNNC. This was done through interviews and field observations. Exploratory data analysis was used to complement user research. User profiles were developed to gain better understanding of users. Task analysis was conducted to describe how SHFBNNC perform their decision making tasks and this served as a guide for visualization and interaction development. Closely working with SHFBNNC, data analytics, an interactive dashboard was designed to address the needs identified. Evaluation of

Table 1. Description of sample data.

Data description	Example	Sources
Household/individual who seek food assistance	<ul style="list-style-type: none"> • number of households and individuals • residence • rates of use, • dietary considerations and health concerns 	Service Insights Link2Feed (L2F)
Poundage Information	<ul style="list-style-type: none"> • total poundage • lbs on own • Store Rescue lbs. 	Monthly Reports from Partners
Fees	<ul style="list-style-type: none"> • Shared maintenance • Rural delivery fees • Food purchase program fees 	Monthly Reports from Partners
Partner agency and food bank operation	<ul style="list-style-type: none"> • Operation hours • Rural delivery date and time • Location of program sites 	Food bank operation file

the dashboard was conducted with real users to test the utility and usability of the system. Several iterations were made to revise the dashboard. Prior to the development, we identified user needs. Several interviews were conducted with two operations managers from SHFBNNC. Due to the pandemic restrictions, virtual interviews were conducted via Zoom meetings. Task analysis was conducted to understand how food bank managers perform their operations tasks. In order to develop the dashboard, we collected data from various sources to support evidence based decision making. Table 1 below provides details of the sample data collected in this research.

With the users centered in the design process, interactive dashboards were developed to meet the user needs. Three interactive dashboards were developed using Tableau to address different user needs.

Various visualization styles and interactivity modes were applied using human factors principles and with the input from the users. The first dashboard addresses the concerns of weekly food distributions of the food bank and their agencies. The second dashboard focuses on poundage information and the third dashboard provides information on impact analysis where food insecurity and annual meal gap were provided for each service area. Heuristic evaluation was conducted to assess the usability of the dashboard. Heuristic evaluation is a discount usability evaluation technique that experts apply design principles/heuristics to measure the usability of an interface. Two experts with expertise in both human factors and food bank operations explored the interactive dashboard and reported usability issues. Design revisions were made based on the heuristic evaluation.

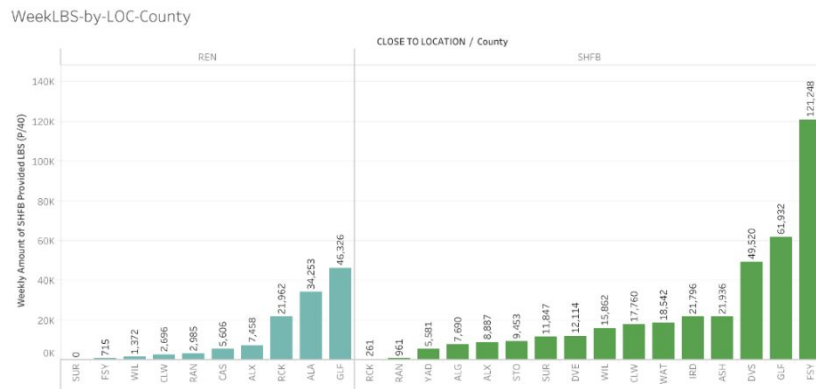


Figure 1: Weekly food distribution by county.

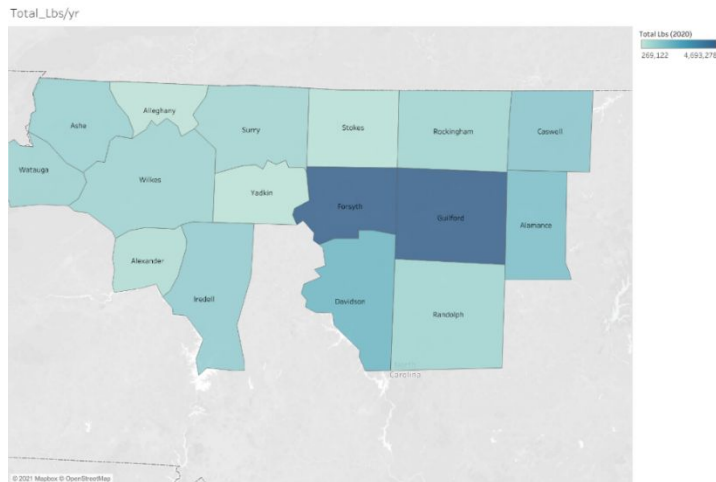


Figure 2: Total pounds per year.

RESULTS

Three interactive dashboards were developed to meet the needs of the food bank to better understand their service area and their service programs. The first dashboard has four tabs each provides information about the weekly food distribution that can assist SHFBNNC managers to make informed decision. These four tabs are: Weekly Food Distribution by County, Weekly Food Distribution by-Agency Location, Number of Agencies in a County, and Weekly Food Distribution. An example tab of this dashboard can be seen in Figure 1. The second dashboard has four tabs that provide information on poundage. These four tabs are: Total pounds per year, Pounds vs. fees for a given year, Proportion of pounds by source, and breakdown of pounds by source. Example tabs can be seen in Figure 2 and Figure 3. The third dashboard provide impact analysis that considers food insecurity and annual meal gap as seen in Figure 4.

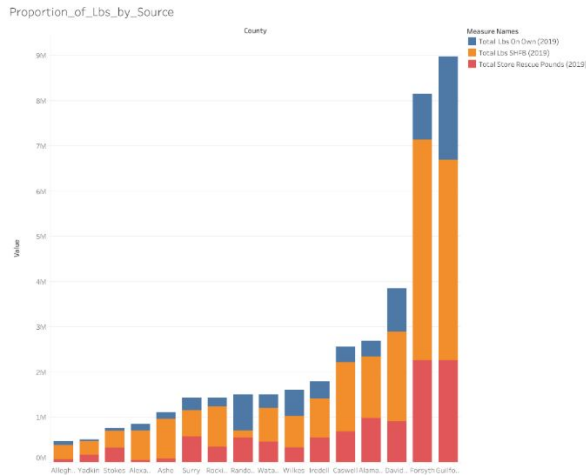


Figure 3: Proportion pounds by source.

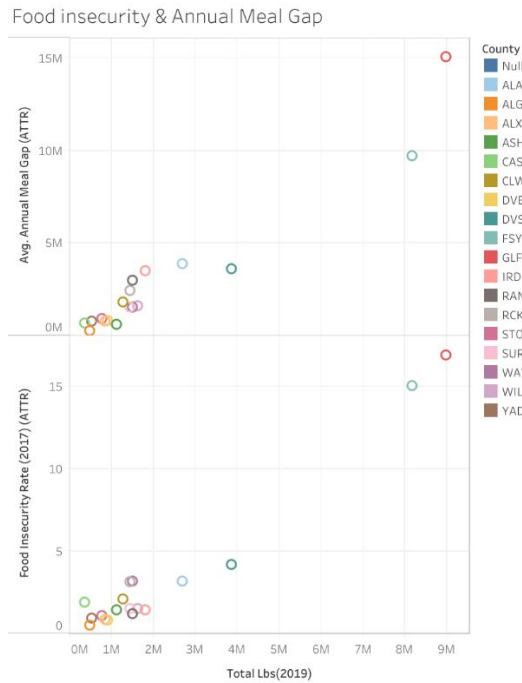


Figure 4: Impact analysis.

DISCUSSION AND CONCLUSION

Food bank operations are very complex and food bank operations managers need assistance to provide evidence based decision making. Food bank data are large, heterogeneous, and messy and it is very challenging for their operations managers to make informed decisions using those data. This research applied visual analytics approach that combines the power of the

analytics and human factors to provide interactive visualizations and dashboards to allow the managers to easily explore the data and interact with the visualizations to make decisions that are based on evidence.

Working with a local food bank, we applied human centered design to the development of the interactive dashboards. SHFBNNC operations managers were at the center of the design process and were closely involved in every step of the design process. Food bank operations are very complex and despite the expertise of human factors engineers, food bank operations managers are the end users of the dashboards and therefore need to be active participants of the design process. This research provided a quick and easy tool for the managers to view the data and visualizations. There are still more work that needs to be done to investigate the possible trends, correlations, and implications of the food bank operations data. Those enhanced understanding of the data will allow the food bank to improve future planning, capacity building, equitable distribution, optimal resource allocation and ultimately contribute to the effort to alleviate food insecurity in the community.

The enhanced understanding of these areas will help the food bank identify opportunities for enhanced efficiencies, well-managed uses of resources and targeted programmatic activities.

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