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A DASHBOARD FOR NURSING HOME COVID-19 IMPACT: A DESIGN SCIENCE APPROACH

Research in Progress

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ABSTRACT

Using a design science approach, we developed a dashboard prototype (artifact) to better understand the factors related to the impact of COVID-19 within nursing homes (NHs). The artifact will allow stakeholders to make informed decisions related to potential spread of the coronavirus in NHs. Data integrated from disparate sources was used for building the design artifact. We used analytics techniques to customize the dashboard and enhance its visualization and interactive capabilities to help stakeholders get answers related to nursing home factors that impact the spread of COVID-19 in NHs. The viability of the dashboard will depend on the attributes possessed, such as the type of information conveyed, the level of detail, and reusability potential. The dashboard can inspire new policies to be developed for nursing home facilities across the country which will ultimately improve their situations in light of the pandemic.

Keywords

Design Science, Nursing Homes, COVID-19, Design Artifact, Dashboard, Visualizations

INTRODUCTION

Since the World Health Organization identified COVID-19 as a Public Health Emergency in Jan 2020, the surge of the global pandemic COVID 19 in the United States has crossed 56 million cases and 825 thousand deaths as per the data provided by the Center for Disease Control (CDC) (CDC, 2022). Much research has suggested that COVID-19 impacts existing health disparities rooted in structural determinants like closed community and long-term health care facilities (add refs here). In addition, settings such as nursing homes have presented significant risks for COVID-19 cases and deaths. As per the data provided by the Centers for Medicare and Medicaid Services (CMS 2021), there were 681 thousand total residents confirmed cases and One hundred thirty-four thousand total residents' deaths. It clearly shows that COVID-19 has negatively impacted nursing homes across the nation.

For this research, it is imperative to understand nursing home characteristics that will allow stakeholders to manage the spread of the virus and reduce the case and death count. Variables such as occupancy rates, infection rates amongst staff members, access to sufficient PPE (personal protective equipment), location of the facilities, staffing levels, county-level cases/deaths trends, demographic information are of great interest and relevance. Many potential factors impact the spread of COVID-19 in nursing homes. One of the significant factors is the increased susceptibility of nursing home patients. They commonly have underlying medical conditions that put them at greater risk than the general population.

This research investigates different factors affecting the spread of COVID-19 in nursing homes through existing knowledge of health care practices combined with additional analysis of nursing home characteristics, personal protective equipment (PPE), community-level factors, and other socioeconomic factors. Much of the data for this is in disparate sources making it difficult to draw meaning full information for needed by stakeholders. Hence, we embark upon a dashboard design artifact, drawing on research from information systems, health care management, prior experience in nursing home administration, public health and health disparities, health care industry processes, emerging technologies, social inclusion, at-risk populations, and health outcomes, to inform the development of this artifact.

BACKGROUND

Nursing Home Characteristics

According to many different studies, nursing home characteristics tend to offer some insight or relationship among COVID-19 cases in nursing homes. My hypothesis is that different nursing home characteristics contain endogeneity with factors difficult to measure or acquire data for. For example, one study suggests “the negative relationship between outbreak and facility size indicates that while smaller facilities are less likely to have outbreaks, outbreaks at small facilities affect more patients per bed. This finding may reflect a number of features of small facilities, such as higher patient turnover and the possibility that isolating COVID-positive residents is more challenging for small facilities (Abrams et al, 2020).” In addition, Mills et al. (2020) states that “characteristics associated with COVID-19 deaths included having patients with higher ADL scores (2.6 PP; $P < .001$), more total beds (0.1 PP; $P < .001$), higher occupancy rates (0.3 PP; $P \leq .009$), and being a for-profit facility (4.8 PP; $P \leq .02$).” The Abrams et al. (2020) study also found that “Larger facility size, urban location, a greater percentage of African American residents, non-chain status, and state were significantly ($P < .05$) related to the probability of having a COVID-19 case.” Nursing home characteristics could potentially provide information regarding the differences in nursing homes and the spread of COVID-19 across these disparities.

Personal Protective Equipment

As individuals obtain more knowledge about the Coronavirus through agencies such as the World Health Organization and the Centers for Disease Control, it becomes more apparent that the best ways to protect oneself from COVID-19 around others are by maintaining a safe distance, washing your hands, or using hand sanitizer, utilizing PPE (generally best practice to wear a face mask), and abstain from touching your face without first washing your hands. This knowledge is enough validation to include the availability of PPE in Nursing Homes the analysis.

Business Problem

To restate the business problem, this project is focused on developing a better understanding of potential indicators for COVID-19 spread in nursing home facilities. There are many potential factors that impact the spread of COVID-19 in nursing homes. One of the major factors is the increased susceptibility of nursing home patients as they commonly have reduced immune systems or underlying medical conditions that put them at an even greater risk than the general population. To transform this problem into an analytics project, we identified the potential factors and available data sources. The factors of focus include demographic data, nursing home characteristics, facility staffing, and personal protective equipment.

Design Science Research

The research project underlying this paper follows the principles of design science research (DSR). Several frameworks outline the key activities that need to be conducted when performing the DSR. Given its clear structure, this paper uses the framework of Design Science in Information Systems research (Hevner et al., 2004). The realm of IS research is at the confluence of people, organizations, and technology (Davis and Olson 1985; Lee 1999). During this creative process, the design science research must evolve both the design process and the design artifact as part of the research. As the first step in a project aimed to improve quality and safety in Nursing homes, a system was needed that delivers real-time information regarding the development of cases from COVID 19. In this paper, the artifact responds to the dashboard, which addresses the need to have a monitoring tool to gain real-time insights and help nursing home managers to take meaningful action to combat and improve COVID 19 situation. Design science addresses research through the building and evaluation of artifacts designed to meet identified business needs. The fundamental principle of design science research is understanding the design problem, which is the through user stories or use cases. Its solution is acquired in the building and application of artifacts, which is the creation of the dashboard.

Design as an Artifact

The term design as an artifact is used to denote activities in a design process. For example, in Unified Process (an object-oriented system development methodology) a "design artifact" is sometimes used to indicate the outcome of a processing activity such as use cases (Larman 1998).

Design-science research must produce a viable artifact in the form of a construct, a model, a method, or an instantiation (Hevner 2004). This methodology begins with observation, which is followed by artifact creation and evaluation. The artifact creation process focuses on the outcome of critical artifacts, including conceptual models, methods, conceptual frameworks, system frameworks, system architectures, and system implementations. The evaluation process is tightly interwoven with the artifact

creation process and supports the evaluation of each artifact independently and collectively and against prior artifacts that influenced their creation. The methodology has been realized and validated in the context of several design science research projects (Ahmed & Sundaram, 2011). We discuss the steps to artifact creation in the context of nursing home COVID impact analysis using the design science research approach in the following subsequent subsections.

Problem Relevance

A research problem helps you formulate the problem relevance sequence. Research problems also help avoid unnecessary steps during the research. The search for a practical problem representation is crucial to finding an effective design solution (Weber 2003). Simon (1996, p. 132) states, "Solving a problem simply means representing it to make the solution transparent." Our objective is to address these problems by proposing a detailed prescription to conduct design science research and instantiate with a practical problem. In this paper, we explore an artifact-centric creation and evaluation approach to integrative design science using an interactive dashboard. Furthermore, we describe the application of our approach to the universal and perennial problem of COVID-19 impact on the nursing homes. We believe that instantiating our implementation-oriented design science approach with this pragmatic topic will enable it to be relevant (Ahmed & Sundaram, 2011).

METHODOLOGY

This study uses a design science research approach (Hevner et al. 2004) to create an IT artifact intended to address the problems. The design science research paradigm seeks to extend the boundaries of human, socio-economic, and organizational capabilities by creating new and innovative artifacts (Gregor & Hevner 2013; Hevner et al. 2004; Sein, Henfridsson, Purao, Rossi, & Lindgren 2011). Given that our research aims to develop dashboard artifacts to help improve the condition in nursing homes, we deem it appropriate to follow the design science research principles to achieve this objective. The project scope is to provide insights at the state and county level. Various resources were used to obtain the datasets, merged for analysis; data wrangling steps help structure the data.

Data Sets

The project scope is to provide insights at the state and county level. Various resources were used to obtain the datasets. The Nursing Home level data across the United States comes primarily from the Center of Medicare and Medicaid Services (CMS). The dataset used is updated weekly and contains 279 variables corresponding to over 15,000 nursing homes that decided to report information. The dataset was already cleaned, prepared, and had time-series data related to cumulative coronavirus cases, deaths, and new cases. Supplemental data used includes the United States confirmed cases, deaths, and county populations. Census data from the year 2019 obtained through the Census Bureau helped estimate census data to account for the demographics at the county level. For the dashboard, we use data over a period of 62 weeks starting from May 24, 2020 to July 18, 2021.

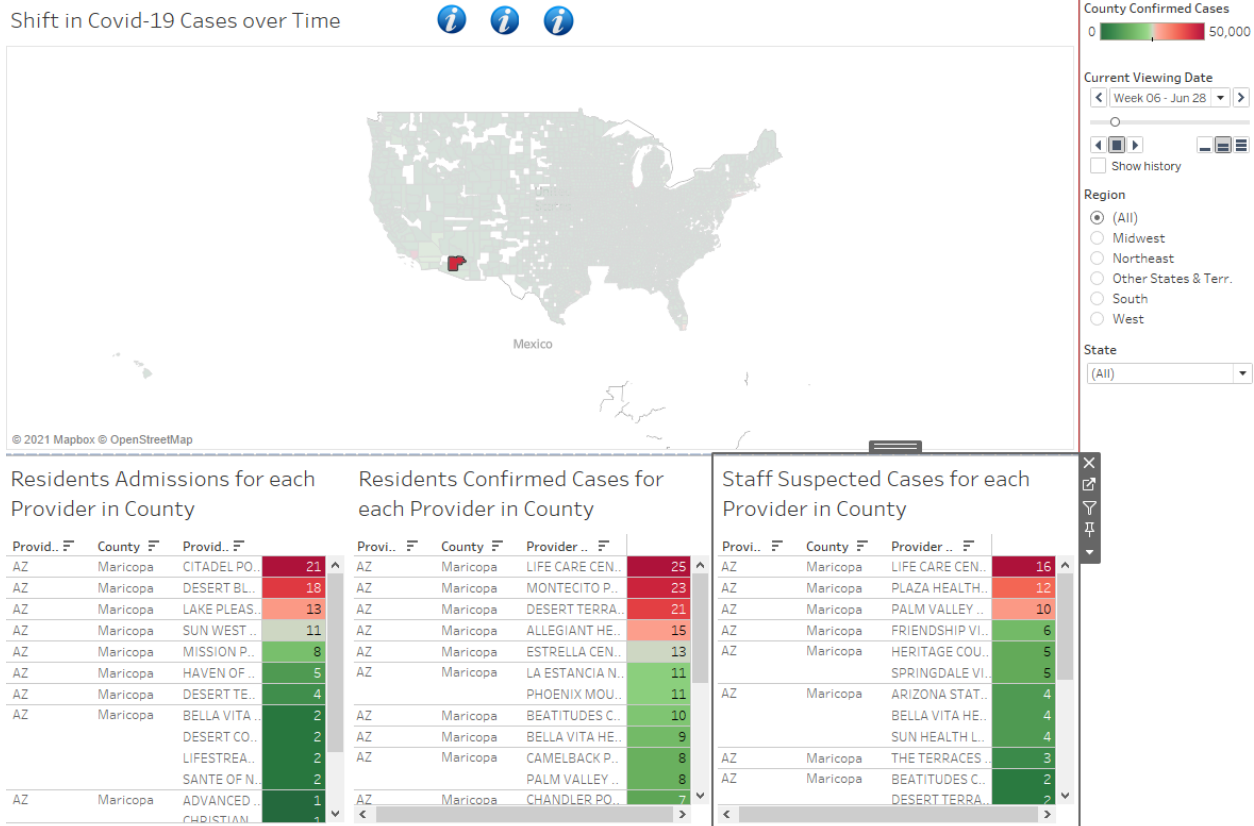
Design Artifact

The design artifact (prototype) can be viewed at <https://msanalytics.github.io/NHDB/>. The visualizations were developed using Tableau and the dashboard was deployed on Github. The design science research in information science addresses the problems or is handled as use cases or user stories. Some of those user stories are:

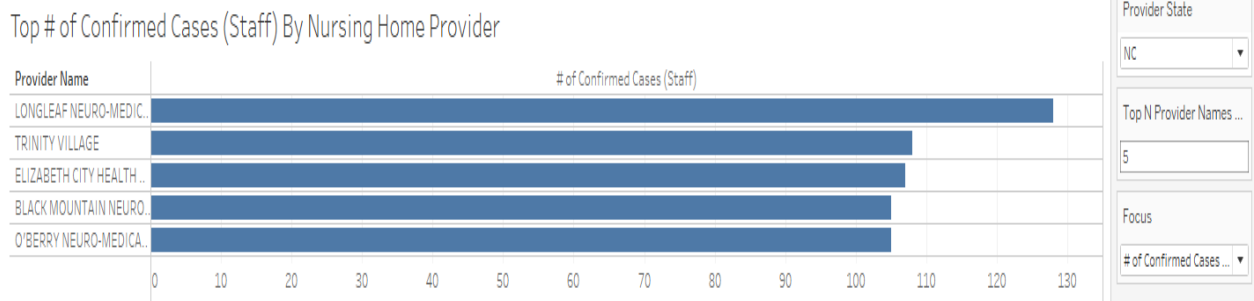
1. We need to know how our infection rates compare to other nursing homes in the region and visualize the factors that indicate the standard of care to improve policies and practices and minimize resident harm.
2. Which nursing homes are experiencing a higher number of cases to determine if support or assistance is needed?
3. What are the trends in COVID-19 infection rates and, if so, how to make appropriate changes to reduce the spread?
4. COVID trends in the local nursing homes for discharge planning purposes.

While four use cases were considered in developing the prototype, one use case is described below. Two snapshots of the interactive dashboard as show here. Figure 1 shows the top nursing homes by county showing resident/staff COVID-19 admissions, cases, and deaths and Figure 2 shows the top 5 providers in NC by staff confirmed cases.

Fig 1 shows the the total resident and staff cases in different counties across different states. Comparing Cook county, IL, and San Bernardino County, CA, it could be gleaned that the staff cases a majority of the time were not too far behind the total resident cases. This relationship was also experienced somewhat with the Total Resident Deaths variable, however with significant variations. After observing the first visualization and comparing the resident cases to deaths, it could be seen that many nursing homes had death counts that were close to or more than half of the total case counts. Others had high case counts but hardly any deaths. It is essential to consider the nursing home's location, such as the region of the country that it is in and whether or not the facility is in an urban area.



By reviewing this model, nursing home administrators and owners should consider minimizing the interactions between staff and patients, leading to fewer cases overall. Based on the literature provided (Shen 2020), it was found that outbreaks in nursing homes were linked to the types of neighborhoods that the staff resided in. Though more analysis should be done to determine whether or not the exact cause can be applied in a stakeholder’s particular scenario, it is still worthwhile to consider the interaction reduction as the relationship strength is too much to ignore. Stakeholders should also consider placing the residents in separate rooms if they have not already done so. It only takes one staff member going into a room with multiple patients to spread to all of them potentially. Furthermore, the number of patients that each staff member interacts with should be reduced as much as possible. By this model’s results, taking these actions specified above should reduce the spread of the virus. It should also be considered that latent factors have not been included in the model but also serve to further the spread of the virus. These factors should be discovered from the datasets and considered in business decisions as well.



IMPLICATIONS

The implications of this study may prove to be valuable for many different stakeholders. If we break the results down by the main factors (nursing home characteristics, facility staffing levels, demographics, and PPE) we can target the results indicating

significance on their impact on nursing home residents. If we consider PPE first, since they encompass a vital role in preventing the spread of the virus, we can see that surgical masks, gowns, and eye protection were consistently significant among all models. Oddly enough, surgical masks have a positive relationship with resident cases. This may be due to some underlying factor that requires certain facilities to carry surgical masks and the nursing homes with this underlying factor may be more susceptible to the spread of the virus. On the other hand, accessibility of gowns and eye protection both had a negative relationship with cases, meaning that nursing homes with more consistent access to such PPE, on average have fewer resident cases than nursing homes without them. This is further justification to support the need for consistent availability of PPE in nursing homes in order to reduce the spread as much as possible. This could have implications for both the nursing home administration stakeholders and Medicare and Medicaid officials to further ensure that the needs of nursing home employees and patients have access to this PPE, or access to sufficient funding in order to maintain the supply of PPE.

County-level trends of COVID-19 cases have a consistently positive relationship with resident cases, which indicates that the spread of COVID-19 within the community is making it into the nursing homes. This also translates to the relationship among suspected and confirmed staff cases. Staff is likely to live within or near the county of the nursing home, and as rates increase in the county, there is a greater potential for staff members to come into contact with the virus and transmit it to patients inside the nursing home. This could potentially put pressure on nursing home administrators and policymakers to ensure that the staff members rotating in and out of the hospital are not infected, which could be done by requiring staff members to take periodic tests and conduct temperature and symptom checks before being allowed to enter the facility. We would also expect that restrictions on visitors to the nursing home facilities be more stringent, especially in counties with higher case numbers in the general population.

The final implications of this study are related to nursing home characteristics. The quality ratings for nursing homes, which encompass many factors in their calculation, have a higher negative relationship with resident cases as the quality rating increases. This suggests that nursing homes with higher quality ratings have a lower amount of resident cases on average. This could be a great metric for comparison with other nursing homes and encourage nursing home stakeholders to identify the differences among their quality ratings and why they are different. In addition, change in ownership within the last 12 months seems to reduce the number of resident cases, which could imply that the nursing homes undergoing a change in ownership are making improvements to their procedures and practices that potentially play a role in reducing the spread of the virus. The changes that nursing homes undergo due to new ownership could serve as a benchmark for other nursing homes. Nursing homes with higher deficiencies and reported abuse flags from their inspections should be monitored more closely as they are expected to have higher resident cases than nursing homes with fewer deficiencies and absence of abuse. Another interesting finding is that nursing homes located in hospitals on average have lower resident cases than that outside of hospitals. This might be due to the restrictions on people entering hospitals and differences in procedures followed. This would be an important characteristic to look into for stakeholders to make decisions about further care and visitation policies.

Overall, the best course of action for nursing home stakeholders would be to utilize the information available to them about nursing homes with the lowest case counts as a benchmark for comparing policies, practices, characteristics, and procedures. We believe this will have the most impact on decision-makers as they might find further insights as to what other nursing homes may, or may not, be doing that prevent the spread of the virus in the facility.

LIMITATIONS

Limitations in this project included the lack of complete data at times and the lack of a variety of data to join together for use. Many columns in the primary dataset lacked data within them, resulting in them being removed from the dataset altogether. Some columns regarded as valuable for visualization lacked data for certain months, making it difficult to compare these metrics against others. This is more of a time issue regarding the variety of data than simply not having the data. For example, there was a lot of rehabilitation information available on the CMS archive. Still, it needed to be understood how to integrate that new data with the existing datasets before using it. There were also issues within those datasets that required explaining, such as the different thresholds for giving star rankings to facilities, which would make it difficult to compare different NHs against each other.

CONCLUSIONS

Using design science research, we created an interactive artifact for exploring Nursing Home COVID-19 Impact. This project's business problem is focused on developing a better understanding of potential indicators for COVID-19 spread in nursing home facilities. Many possible factors impact the space of COVID-19 in nursing homes. One of the significant factors is the increased susceptibility of nursing home patients. They commonly are immunocompromised, which puts them at greater risk than the general population. For the analytical solution to the problem, we must identify the potential factors and available data sources. This can be done through the development of a theoretical framework supported by a literature review. The focus factors

include demographic data, nursing home characteristics, facility staffing, and personal protective equipment. The dashboard artifact created from this study will help the case city authorities and stakeholders of the nursing home to better visualize the data in a more smart and realistic way so that they can make informed decisions in improving COVID - 19 impact on the nursing homes. The study outcomes will help the case study nursing home authorities and stakeholders to overcome the current constraint of having the valuable data in one place via a dashboard for easy accessibility and analysis. Our next steps are to conduct evaluation of the dashboard through users' feedback. This will help us further refine the design artifact

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Data Sources

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2. USAFacts(<https://usafacts.org/visualizations/coronavirus-covid-19-spread-map/>)
3. CMS Rehab Info (<https://data.cms.gov/provider-data/archived-data/nursing-homes/>)