

The Impact of COVID-19 on Food Security and Delivery in the California Central Coast Region

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Abstract

The COVID-19 pandemic has impacted the supply chain of food all over the United States. This research is concerned with the direct impact on the population living on the California Central Coast in need of food security. Notably, we are looking at food banks and produce distributors in San Luis Obispo and Santa Barbara Counties. This paper aims to research the effects of COVID-19 on food access, availability, and transportation regarding food banks and local farms. The combination of uncertainty in demand and reduced access to markets and vendors resulted in more food insecurity among marginalized communities that are already at a higher risk for contracting COVID-19. We will explore methods and models that attempt to account for the lack of access. We also plan to analyze the supply chain for food transportation pre-COVID and what areas experienced bottlenecks. Possible challenges that lie ahead will also be discussed.

Keywords

COVID-19, Food Security, Food Banks, Supply Chain, Central California

1. Introduction

Food banks help distribute food to those who have difficulty purchasing food. When the COVID-19 pandemic spread in the US, there was a sharp increase in unemployment due to many businesses closing during the lockdown. It was also common for grocery stores to experience stockouts in nonperishables and other essentials due to fear of not having these resources during a lockdown. This led to an increase in people relying on food banks due to unemployment and limited grocery store resources. Food banks had to adapt and find a way to cope with their rise in participants with the same resources during normal operations. Investigating their mitigation and supply chain methods can help with the analysis of the situation and what adjustments can be made to help more people with food insecurity. This research will also apply to future disasters that need relief.

Our research will investigate how food banks responded to the increase in food insecurity during the COVID-19 pandemic in the central coast region of California. We will identify struggles and obstacles food banks have faced and will continue to face by identifying what aspects of their supply chains were most impacted by the pandemic. Using our research, we will recommend solutions for these food banks and any in the future on how to best protect the people who require food banks' services to survive during crisis events such as pandemics and other natural disasters.

2. Literature Review

According to Gokham (2010), the success of a supply chain depends on the product design and its supply chain capabilities. A process called Design for Supply Chain aims to reduce cost, improve quality, improve efficiency, and improve profitability. This process looks at product design choices and looks to minimize costs later on in its supply chain life cycle. An example would be to design the packaging for the most effective transportation and storage. For food banks, profitability is not a goal, but keeping costs down is. If they don't keep costs down, they will go out of business and not help the people who need food the most. Design for Supply Chain will be looked at when considering

our recommendations in our research's conclusion section. This could involve redesigning packaging to be able to reach more people with the same amount of resources.

According to Angeles (2009), RFID tags use radio waves to identify an object's position in the supply chain. This real-time track and trace technology allows the supply chain a new and heightened level of visibility. The RFID tags have both a microchip and an antenna. These allow the tag to store and transfer information. RFID tags are a step up from the typical barcodes and magnet strips that are used for supply chain data collection. They are also a step up in price but if particular goods are necessary to the food bank's supply chain, we may recommend using these RFID tags. These tags could be integrated into pallets or larger units to keep track of moving inventory and can assist in production planning.

According to "Research and Markets: Delivering Performance in Food Supply Chains" (2005), there are six challenges when managing a food supply chain. These include: managing relationships, aligning supply with demand, maximizing efficiency, quality and safety, using technology effectively, and promoting sustainability. One of the critical points that we will focus on is aligning the supply with demand. During a pandemic, there is often a great demand with limited supply. We will use our process improvement tools to make recommendations on how these food banks can get their food supply to those in need while maintaining the six expectations.

According to Taylor (2005), many agricultural supply chains have enormous opportunities for improvement. This was seen when a pork supply chain was analyzed in 2002. They wanted to look at the efficiency from the producer all the way to the consumer. By constructing a value stream map, they identified the most critical paths where improvements could be beneficial. Once improvements were made, a reconstructed value stream map was created to refocus on different critical paths. Using this strategy of continuous improvement, they were able to streamline the pork production process. This study shows that critical paths can be continuously improved in many types of food to make the production process as LEAN as possible.

An essential aspect of the supply chain is to map out the discrete activities. Pucko (2004) emphasized this when studying food supply chains in Slovenia. When you break down a supply chain's activities into the smallest components, the ERP manager can make decisions on where to focus. Different activities can be giving a company a competitive advantage or a disadvantage. We may recommend that if a food bank is struggling, they should break down their supply chain into discrete activities. This way, we will be able to quantify better how much these particular activities are costing the company and how we should go about improving them.

Supply chain resilience is a massive aspect of our project. We want to see how food supply chains held up during the COVID-19 pandemic. Similarly, Gamage and Olapiriyaku (2020) looked at how supply chains in Thailand held up during floods. The study focuses on a diagram called the resilience triangle. It displays three stages of recovery: impact, degradation, and recovery as they pertain to time. By diagramming these stages, one can see which stage needs the most attention and then can alter supply chain decisions to lower stage times. We will be looking for which stage of the food supply chain takes the majority of the time and supply chain decisions that can improve its recovery time.

Jadhav et al. (2009) focus on Supply Chain Organization Theory. This is a theory that the company's supply chain is a separate entity from the company and that it should be judged individually. This in-depth reflection on the supply chain will cause the company to address better supply chain issues that may arise. For the supply chain of food banks, we will recommend an in-depth review of any supply chains that are not meeting the company's needs. We hope this will in turn, cause the food bank to identify entities of the supply chain that need to be reworked.

According to Abensur (2020) and Patne (2018), algorithms were constructed to aid in location-allocation as well as pricing-inventory decisions using a two-stage process. The first stage used Particle Swarm Theory to develop an algorithm to prevent premature convergence. This means that the company is targeting the products to arrive right on time to avoid storage costs. The second phase used the results from the first stage to accurately price goods according to their transportation and storage costs. This study highlights a key point about premature convergence that could be a useful recommendation to food banks.

Cold supply chains are supply chains involving any goods that need refrigeration. Al Theeb (2020) looks at how these particular supply chains can increase efficiency despite their challenges. They developed a model that reformulated

travel routes and scheduling to minimize the amount of time the foods were in transportation. These reductions helped lower the distribution costs by 9.25%. Many food banks rely on some refrigerated goods. We will recommend that these food banks look into reworking scheduling and transportation routes to cut costs.

3. Methods

Data was collected through outreach to California central coast food banks and produce donation programs to compare the experiences felt by different operations in this region. A series of questions was asked to each operation so the answers could be compared when we analyze their responses. The questions are listed here:

- 1) How many food banks do you have contact with?
- 2) Was it harder to receive goods from farms in the area or distributing the goods to the community?
- 3) Were there differences in process or delivery times?
- 4) How did shortages from stores affect supplies?
- 5) Which groups were most affected by the food shortages during COVID-19?
- 6) What services or events had to be canceled due to COVID-19?
- 7) What complaints/comments have you received during the pandemic from food banks that you have been in contact with?
- 8) Were there complaints from the community?
- 9) Has there been food spoilage or contamination? To what extent?
- 10) How were problems dealt with initially?
- 11) Average delay for shipments? (compared to non-COVID-19 times)
- 12) As time has gone on through the pandemic, have things gotten better or worse?
- 13) Did you receive assistance from the government? What type?

The reasoning behind these questions is to receive a blend of qualitative and quantitative data to tell a complete picture of what happened in the food bank ecosystem from March 2020 to October 2020 during the beginning of the COVID-19 pandemic in the United States. These operations had to undergo fundamental changes in these months that left an undeniable mark on the industry as a whole that will need to be accounted for in any future food banks on the central coast of California and elsewhere.

4. Data Collection

4.1 Case Study 1 (Santa Barbara, CA)

Over the last six months, a food bank in Santa Barbara County has been impacted by the pandemic in several different ways. Donations from small and large stores called "Retail Rescue" decreased by 50% between March and July. During the pantry run starting in March, many grocery stores were left with empty shelves, especially canned goods and nonperishables. This impacted the food bank's supply for these types of goods, making it more difficult to purchase nonperishables for their community and reduce the number of donations received. The annual budget for purchasing food is \$400,000, yet they spent \$500,000 in three months over the summer of 2020. Lead times for buying food from wholesale vendors increased by 200-400%, going from 2-3 weeks to 6-8 weeks. Food output has doubled during the pandemic, with their warehouses acting more as a throughput house, going from a 12-day inventory supply to a 5-day inventory supply. They also added two more warehouses and now have a total of four. In a typical year, they provided 9.5 million lbs annually, yet this year in just seven months during the pandemic, they have supplied 14 million lbs. Before the pandemic, approximately 25% of their food was supplied by the government, 15% was purchased, and 60% was donated by distribution centers (DCs) around the nation and large companies like Walmart. When the pandemic first hit with nonperishable shortages, there was a lack of response from the USDA until July, yet increased support will halt this fall with the Family's First COVID Act ending.

Other federal emergency services like FEMA provided nearly no support using the reasoning that unemployment isn't a "disaster" they justify providing relief for. A new government-funded program may take more time with it being an election year, increasing food banks' pressure this winter. Campaigning has increased in hopes of receiving more donations during the fall, especially with the fear of a second pantry run or stockout during the holiday season and possible lockdown. Donations have increased for produce because of restaurant shutdowns, fewer people going out, and households purchasing more nonperishables. Since Santa Barbara County is surrounded by produce-rich land, a few large farms provide for the food bank, and donations increased by 200% with no delay in delivery times. The

issue the food bank faced with this increase in produce was risking spoilage in the warehouses. When this occurred, they sent the produce to animal farms and compost, leaving less than 1% of the food in landfills. The food bank has about 300 agency partners that can take orders from the bank and distribute food at pantry sites and other organizations. They also provide for retirement homes, delivering to residential shelters and special housing. They have set up pre-pack operations at warehouses to reduce the risk of people congregating at other sites to pack food. To relieve people of food insecurity, the food bank wants to help get people on the food stamp program, CalFresh, and increase donations received through campaigning and raising awareness on how food banks help community members, especially those more heavily affected by the pandemic. The COVID-19 pandemic has been the longest sustained "disaster" the food bank has dealt with, and it has changed how they operate and how the community perceives them.

4.2 Case Study 2 (San Luis Obispo, CA)

A food bank in San Luis Obispo, CA which serves the entirety of San Luis Obispo County through 80 industry partners ranging from free-food pantries to Salvation Army groups saw a 300% increase in participants requiring support from the food bank and no conclusive evidence that the surge in demand would end quickly. The food bank believes that it will see these unprecedented demand levels for up to two years after the initial spike on March 10th, 2020. The phenomenon that occurred alongside the spike in demand for food bank services was the surge in customers buying out nonperishable and hygienic supplies from grocery stores that these food banks use to supplement orders if they do not have everything that is needed on hand. This led to an over-reliance on shipments from suppliers directly whose lead times increased across the board and unpredictably based on which product was selected and which supplier was chosen. These lead times went from a maximum of 7 days to 6+ months, as reported in March 2020. This uncertainty led them to the option of government aid from the FDA and USDA, which was not an established form of donations until late July 2020 for the San Luis Obispo Food Bank. By September 2020, the situation has improved with suppliers regaining control of their supply chain and a slow wean of participants in food bank programs as the central Californian coast's economy recovers. The food bank has also established greater utilization of volunteers in their network to streamline the cleaning, sortation, and distribution process at their distribution centers and partner locations.

4.3 Case Study 3 (San Luis Obispo, CA)

A gleaning program that is an extension of a local food bank is focused on harvesting unwanted produce or produce that would go to waste. All the produce that is gleaned is routed through the local food bank and over 80 agency partners of the food bank. For clarity, food banks seldom do much "direct distribution" of food to individuals, and rather, they distribute food on a larger scale, routing food from the food bank warehouse to agency partners, who are the primary resource for individuals and families receiving food. Having that said, the program does keep contact with a large network of food banks and glean programs, but never sends produce out of SLO county.

During the initial months of the pandemic, any in-person events outside of basic operations were initially canceled. The entire gleaning program was put on pause for about a month and a half and eventually resumed with increased safety protocols. The program avoids any sort of recreational/non-operational in person events and instead does education and outreach through virtual platforms. They were met with a similar increase in demand, as families who had lost their jobs became reliant on the food bank. Despite being unable to deploy a team of harvesters to gather the produce directly, long-time partners continued to ship donations to the program. Regular produce donors such as local universities donated larger quantities of produce, as they saw a decrease in demand from commercial industries. Overall, they did not see any slow down on their procurement, and their produce levels were not negatively affected.

5. Results and Discussion

5.1 Numerical Results

In our case studies, we saw the demand dramatically increased. The SLO food bank saw a 300% increase in demand. The SB food bank also saw an increase in participants by almost 200%. Due to the rise in demand, the amount spent on food orders also significantly increased. In the case of the SB food bank budget of \$400,000 was surpassed in three months, with \$500,000 being spent. Pounds of food distributed reflected the amount spent. In SB, 9,821,287 lbs of food were distributed in 2019, but in 2020 the amount increased to 14,176,543. 2021 is seeing similar results, with 14,559,314 lbs of food already distributed. The USDA didn't help to any degree until July to compensate for the increase in spending. Lead times were also impacted, with SB seeing a 200% increase and SLO seeing lead times up

to 6+ months for goods whose lead time was 2-3 weeks previously. Overall, in all case studies, there was an increase in funding, lead times, and food distribution, allowing the food banks to catch up with their surge in participants.

5.2 Graphical Results

Figure 1 and Figure 2 both chart the pounds of food distributed by a Santa Barbara food bank with forecasts for the end of 2020 and the beginning of 2021. The sharp spike from March to June of 2020 occurred after grocery store stockouts and many lockdowns went into effect, leading to unemployment.

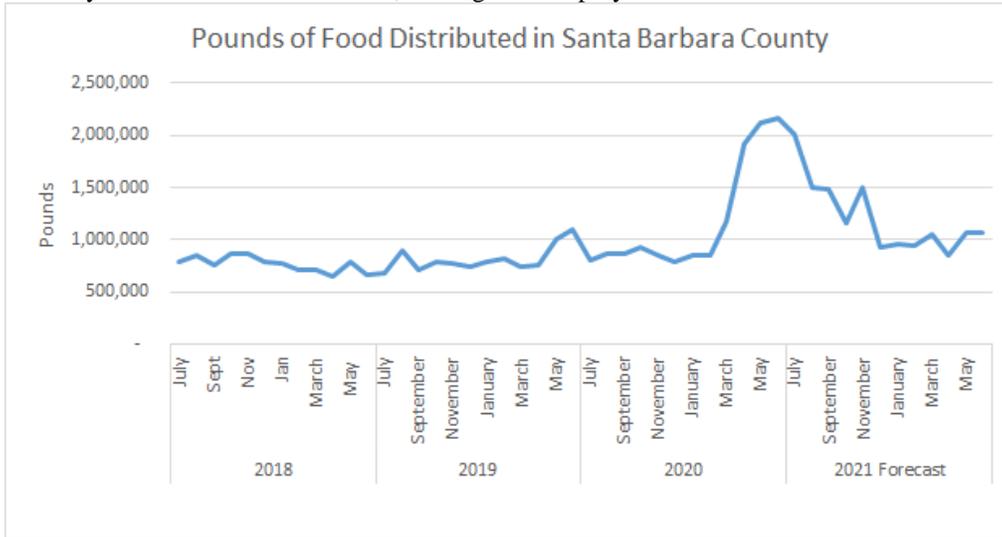


Figure 1. Pounds distributed by a Santa Barbara food bank by month

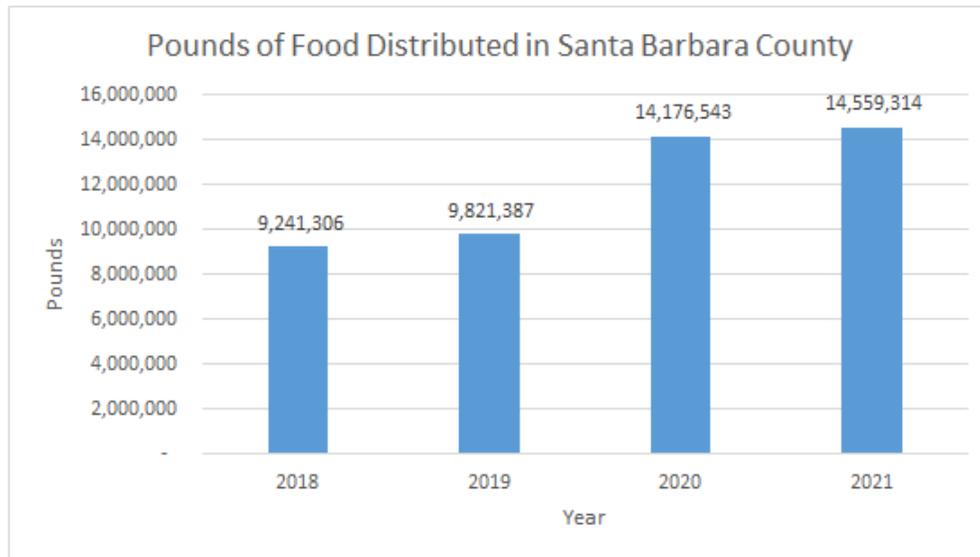


Figure 2. Pounds distributed by a Santa Barbara food bank by year

5.3 Proposed Improvements

Reallocating resources and funding as soon as a natural disaster becomes apparent, the cost of citizens starving. This would make agencies such as FEMA provide relief in the form of food and transportation to people affected by food insecurity. Meet with media outlets and government programs to inform and discuss the media portrayal of food stockouts to decrease the fear of shortages of nonperishables and other foods. Stores can also limit the number of nonperishables each household can purchase to ensure more families can access these goods during a stockout. Alternative packaging methods can be created to mitigate the aluminum can shortage from households stocking up on

nonperishables. Evaluate and improve the USDA and other federal resources' response process to massive deficits and food banks to allow faster processing to provide relief to their agencies. This can include upgrading suppliers' MES and ERP systems to allow for scalability and transparency in production, which can support changes in demand more efficiently and productively. The food banks can set aside funding to be used only in case of emergencies such as pandemics and other crises that spike demand for food. The government can also set aside a safe account of sorts to be given to food banks when additional funding is needed due to a crisis. Increase support to people unemployed due to massive layoffs caused by disasters such as pandemics due to multiples businesses closing. It has been evident that much of the public and government is not prepared for the effects of pandemic type disasters. All of these possible solutions result from looking at where food banks in the Central Coast had issues in their supply chain and how they have already tried to handle the shortage. With more awareness among each community, the people and government can more effectively respond and support those most in need.

5.4 Validation

Validation to back up the proposed improvements includes a process analysis of time of the USDA response process. This would include testing and designing a new MES and ERP system for suppliers of high-demand food to adjust production according to fluctuating demand, especially for a ramp. Increasing funds would include conducting a cost analysis on pandemic scenarios to know the amount of funding needed to be set outside or to provide and to who during a pandemic. This validates the improvement to set up safe funding for food banks. Evaluating the decision of FEMA and other emergency services that the massive unemployment and food insecurity caused by the pandemic to be seen as a disaster that didn't need relief so there may be more food security in the future for those unemployed.

6. Conclusion

The unprecedented increase in food insecurity due to economic instability caused by the COVID-19 pandemic in 2020 has sparked a paradigm shift in the food bank network across the United States. This research has documented the shortcomings of the established system, and overwhelming evidence shows that a significant number of food banks were significantly underprepared for a 300% increase in participants in their programs. This resulted from the record high unemployment rates in this region, product hoarding diminishing the supply of wholesale grocers rapidly, and assistance from the federal government coming after several months into the pandemic.

References

- Gokhan, N. M., Needy, K. L., P.E., & Norman, B. A. (2010). Development of a simultaneous design for supply chain process for the optimization of the product design and supply chain configuration problem: EMJ. *Engineering Management Journal*, 22(4), 20-30. Retrieved from <http://ezproxy.lib.calpoly.edu/login?url=https://www-proquest-com.ezproxy.lib.calpoly.edu/docview/863241988?accountid=10362>
- Research and Markets: Delivering Performance in Food Supply Chains - Identifying Six Key Challenges in Managing Food and Drinks Supply Chains. (2009, Dec 03). *Business Wire* Retrieved from <http://ezproxy.lib.calpoly.edu/login?url=https://www-proquest-com.ezproxy.lib.calpoly.edu/docview/443736643?accountid=10362>
- Angeles, R. (2005). RFID TECHNOLOGIES: SUPPLY-CHAIN APPLICATIONS AND IMPLEMENTATION ISSUES. *Information Systems Management*, 22(1), 51-65. Retrieved from <http://ezproxy.lib.calpoly.edu/login?url=https://www-proquest-com.ezproxy.lib.calpoly.edu/docview/214123408?accountid=10362>
- Taylor, D. H. (2005). Value chain analysis: An approach to supply chain improvement in agri-food chains. *International Journal of Physical Distribution & Logistics Management*, 35(9), 744-761. doi:<http://dx.doi.org.ezproxy.lib.calpoly.edu/10.1108/09600030510634599>
- Pucko, D., PhD., & Tomazic, B. (2004). *Strategic Analysis Of A Company Based On The Value Chain Approach With The Fructal Company Case*. Zagreb: University of Zagreb, Faculty of Economics and Business. Retrieved from <http://ezproxy.lib.calpoly.edu/login?url=https://www-proquest-com.ezproxy.lib.calpoly.edu/docview/217749058?accountid=10362>
- Gamage and Olapiriyakul. (2020). Flood-resilient Supply Chain Network Design: A Case Study of Eastern Thailand. 2020 IEEE 7th International Conference on Industrial Engineering and Applications <https://ieeexplore-ieee-org.ezproxy.lib.calpoly.edu/document/9102103>

- Akshay Jadhav, Stuart Orr, Mohsin Malik, The role of supply chain orientation in achieving supply chain sustainability, International Journal of Production Economics, Volume 217, 2019. <https://www.econbiz.de/Record/the-role-of-supply-chain-orientation-in-achieving-supply-chain-sustainability-jadhav-akshay/10012129240>
- Eder Oliveira Abensur, Alexandre da Silva Paes, Erick Reyann Kasai Yamada, Vito Ruggieri, Walquiria Alves de Aquino, Tao Peng. (2020) Stochastic facility location problem in a competitive situation: A game theory model for emergency financial services. Cogent Engineering 7:1. <https://www.tandfonline.com/doi/pdf/10.1080/23311916.2020.1837411>
- Kalpit Patne, Nagesh Shukla, Senevi Kiridena & Manoj Kumar Tiwari. (2018). Solving closed-loop supply chain problems using game theoretic particle swarm optimisation, International Journal of Production Research. <https://www.tandfonline-com.ezproxy.lib.calpoly.edu/doi/citedby/10.1080/00207543.2018.1478149?scroll=top&needAccess=true>
- Nader Al Theeb, Hazem J. Smadi, Tarek H. Al-Hawari, Manar H. Aljarrah. (February 10, 2020). Optimization of vehicle routing with inventory allocation problems in Cold Supply Chain Logistics, Computers & Industrial Engineering. <https://doi.org/10.1016/j.cie.2020.106341>.

Biographies

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Maria Brown is a fourth-year Industrial Engineering undergraduate student. She is interested in project management, consulting, and data analytics and is also working at LAM Research as a Business Function Intern. She has enjoyed projects in Power BI, Operations Research, and Process Improvement.

Sean Love is a senior Industrial Engineering student. He is interested in construction and plans to work in the Los Angeles area. He was an intern at a small engineering company but wants to work for a more prominent company. He is a member of the HVAC and R clubs on campus.

Keven Nieto-Ramirez is a fourth-year undergraduate student in Manufacturing Engineering. He is interested in metallurgy and plans to go to graduate school for materials science. He is a member of the Society of Manufacturing Engineer (SME) club on campus. He has worked on casting projects with professors and volunteered at the Innovation Sandbox, a 3D printing service, on-campus.

Bruno Zac is a fifth-year Industrial Engineering student at Cal Poly. He has work experience with automated systems and product scheduling in the logistics field. He plans to join Associated Packaging Inc. post-graduation. He is also a member of the Sales Engineering Club on campus.

Mohamed Awwad is an Assistant Professor in the Department of Industrial and Manufacturing Engineering at California Polytechnic State University (Cal Poly), San Luis Obispo, CA. He received his Ph.D. and M.S. degrees in Industrial Engineering from the University of Central Florida, Orlando, FL, USA. Additionally, he holds M.S. and B.S. degrees in Mechanical Engineering from Cairo University, Egypt. Before joining Cal Poly, San Luis Obispo, Dr. Awwad held several teaching and research positions at the State University of New York at Buffalo (SUNY Buffalo), the University of Missouri, Florida Polytechnic University, and the University of Central Florida. His research and teaching interests include applied operations research, logistics & supply chain, blockchain technology, distribution center design, unconventional logistics systems design, and OR applications in healthcare and the military.