

**HOW AMBULANCE DELIVERY SYSTEMS MARGINALIZE LOW-INCOME
AND RURAL COMMUNITIES**

A Research Paper submitted to the Department of Engineering and Society
In Partial Fulfillment of the Requirements for the Degree
Bachelor of Science in Biomedical Engineering

By

Nishita Ardhapurkar

March 25, 2021

On my honor as a University student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments.

ADVISOR

Catherine D. Baritaud, Department of Engineering and Society

In the last few years, healthcare costs have been rising at high rates. Healthcare spending in the United States in 2017 grew by 4.2%. In 2018, spending grew by an even higher percentage of 4.6% and reached approximately \$3.6 trillion or about \$11,000 per person (Center for Medicare and Medicaid Services, 2019, p.1). Due to the increase in healthcare spending, naturally, the cost of ambulances has increased as well. However, the rise in costs is not necessarily associated with better care. Rural and low income areas continue to be marginalized when it comes to ambulance service. High costs for ambulances make it difficult for low income households to receive care, and even when they do, the care is inefficient. Furthermore, high cost differences between in-network and out-of-network care make it even more difficult to afford care when needed. This is exacerbated with ambulances as patients are not able to choose their ambulance provider so the high bills they receive are completely out of the patient's hands (MedPac, 2013, n.p.).

The technical project aims to further analyze the lack of access to healthcare in rural communities. The project gathered and used market research to develop an optimization model for air ambulance locations with the goal of increasing accessibility to patients while lowering costs associated with the transport. It provides a better understanding of the current air ambulance transportation network and how the industry and policymakers could modify allocation to improve healthcare outcomes for patients.

The STS project aims to investigate the specific factors that influenced the development of ambulance delivery technologies. Through this, a better understanding of the biases in ambulance delivery technologies could be achieved. Social Construction of Technology (SCOT) analysis will be used to investigate ambulance delivery systems (Pinch & Bijker, 1987, n.p.).

Through this approach, the social aspects that affected the development of ambulance delivery system will be analyzed.

Both the technical and STS project research ways to make ambulance delivery more efficient overall in order to better serve the population. The technical project involves creating an optimization framework that would place air ambulance base locations such that access to patients will be improved. The STS project investigates how the technology in ambulance delivery systems marginalize low income and rural communities. This project would determine key weaknesses in the system that would need to be rectified in the future.

HEALTHCARE DISPARITIES, UNEQUAL ACCESS, AND SUBJECTIVITY IN AMBULANCES

The air ambulance industry must deal with several issues such as high cost, patient

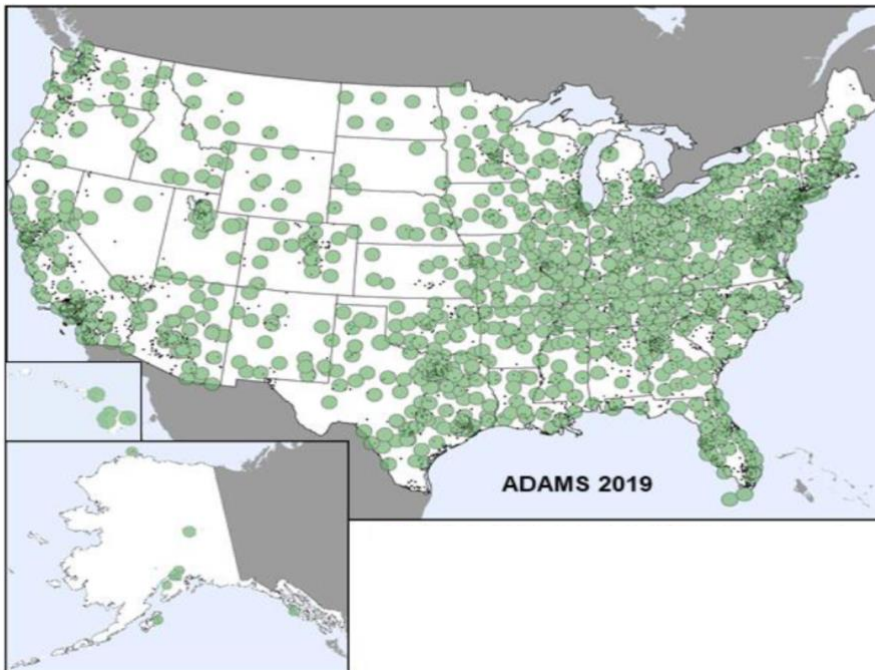


Figure 1: Air ambulance allocation in 2019 overlaid onto map with population density (The Association of Air Medical Services, 2019)

outcomes, and health equity. Currently, air ambulance providers are distributed to emergencies without knowledge of the patients' health insurance coverage (MedPac, 2013, n.p.). The cost of using an out-of-

network ambulance provider is exorbitant and many low income households would not be able to pay that price. This contributes to high health care costs in the US and deters low income households from getting the care they need. Furthermore, air ambulance bases are currently localized around urban areas, so access to rural areas is greatly reduced (United States Government Accountability Office, 2019, n.p.). Figure 1 on page 2 shows the allocation of air ambulances and population density in 2019. Each black dot in the image represents 10,000 people, and the green circles represent the location of air ambulance bases and an area where a 15-20 minute response time can be achieved. In the image, many black dots are visible that are outside of the green circle. An estimated 42.5 million people live outside of a 20 minute response time circle from an air ambulance base (The Association of Air Medical Services, 2019, p. 16). This means that a 20 minute response time, which is imperative in some emergency cases, cannot be achieved for 42.5 million people. In the rural U.S., there are an estimated 85 million people who without air ambulances, would be unable to reach a health care facility within an hour after the injury or illness has occurred (Hinsdale, 2018, p. 2). Rural communities' reliance on air ambulance travel is increasing as rural hospitals close down, so it is imperative that they get the access they need (McCausland, 2019, n.p.).

GEOGRAPHIC AND INCOME DISPARITIES

Rural and low income areas are also most affected by the rising cost of healthcare, and high out of pocket costs for ambulances deter members of these communities from getting the help they need. Low income countries lack an organized emergency system (Suryanto et al., 2017, n.p.). Similarly, current ambulance systems are not built to care for low income and rural states and counties. The delivery systems are built using urban populations as a model. Urban

communities are built completely different than rural communities so the models are not transferable to rural populations (Wong et al., 2019, n.p.).

Ambulances are exceptionally inefficient in delivering fast care. One study found that ambulance response times are much higher for emergencies in low income communities than high income communities (R. Y. Hsia et al., 2018, n.p.). Patient outcomes after certain health events, such as cardiac arrest, largely depend on the speed of treatment. Even a few minutes in delay of treatment could be the difference between life and death. In the case of cardiac arrest, treatment needs to begin immediately to have the greatest effect. A stopped heart means that no blood is being pumped through the body, and more than 20 minutes in this condition greatly increases the likelihood of brain death (Rogers, Rittenhouse, & Gross, 2014, n.p.).

One study found that rural residents were more likely to die after a trauma incident than nonrural residents (Jarman et. al., 2016, n.p.). This could be linked to the higher response times for rural communities.

RACIAL DISPARITIES

Race and income are not completely separate issues. Income disparities in healthcare have racial bias embedded in them, as low income black families are more likely to be in poverty than their white counterparts (Simms, Fortuny, & Henderson, 2019. p. 3). Low income neighborhoods are more likely to be populated with minorities. However, there are some disparities that can be specifically tied back to race. The life expectancy for the white population in America is about 78 while the life expectancy for the black population is starkly lower at 72 (Arias, Tejada-Vera & Ahmad, 2021, p. 3). This was made alarmingly clear during the COVID-19 Pandemic when black people were disproportionately affected by the coronavirus, due to a combination of a lack of healthcare and the nature of their jobs which did not allow for proper

social distancing. One study showed that minority population were more likely to be subject to an ambulance diversion (Hsia et al., 2012, n.p.). Ambulance diversions take place when a hospital is overcrowded and the ambulance must take the patient to a different hospital. This delays care for that patient which could lead to worse outcomes.

In order to make the healthcare system less biased, the causes of racial and income disparities in the healthcare system must be analyzed. When the weaknesses are understood, new systems can be put into place that rectify the current disparities. This will lead to better patient outcomes as patients in rural and low income communities will get care faster. In many cases, faster care means better results.

AMBULANCE DISPATCH

Ambulance dispatch is a very subjective and complex process. Figure 2 shows the multiple steps required in ambulance dispatch. Many of these steps require human intervention which increases the subjectivity involved in ambulance dispatch.

One of the major problems with ambulance dispatch is communication, or the lack thereof (Institute of Medicine, 2011, p. 32). The dispatcher may not be able to hear the person on the other end of the call and therefore may not be able to deliver care. The dispatcher may also not be able to

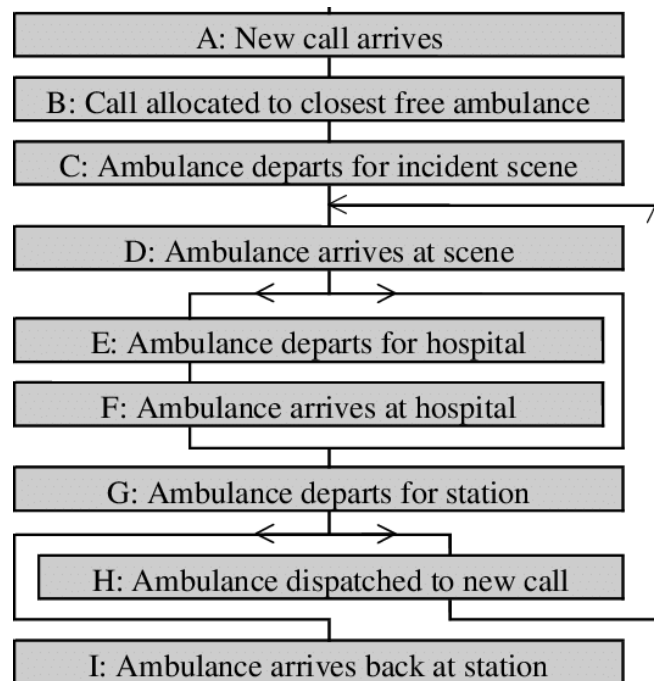


Figure 2: Outline of ambulance delivery system (Henderson & Mason, 2005)

understand the person calling in an emergency which would disproportionately negatively affect immigrants in getting care.

Also, dispatchers may have to triage, determine which calls get priority, if there is a lack of resources. This could severely increase the subjectivity and bias involved in dispatch, as it puts people in charge of very big decisions. Implicit and unconscious bias can be a major factor in the decisions dispatchers make. Since this bias generally goes unaddressed, its consequences can get compounded as the dispatchers make more decisions. As ambulances are not yet completely dispatched automatically, subjectivity in dispatch is a major problem in achieving equal access.

SOCIAL FACTORS AFFECTING THE DEVELOPMENT OF AMBULANCE

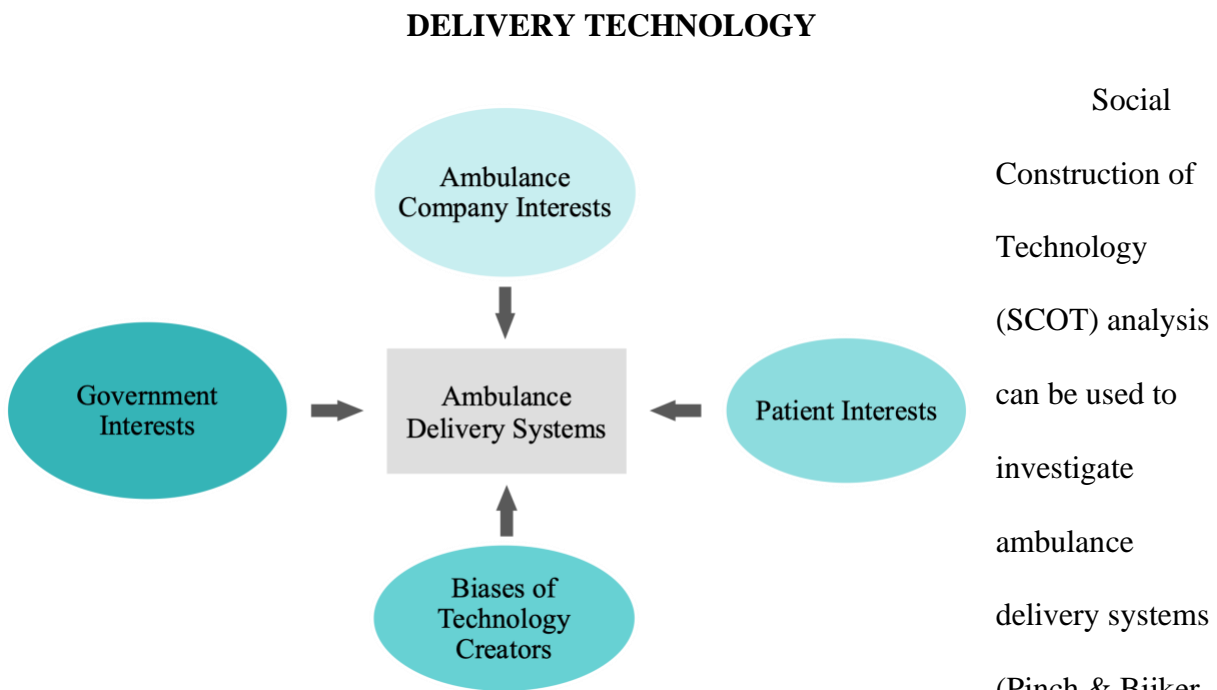


Figure 3: Factors that affect ambulance delivery systems (Ardhapurkar, 2020)

social aspects that affected the development of ambulance delivery system can be analyzed. Four factors will probably have the most effect on the development of the ambulance delivery

systems; government interests, the biases of technology creators, ambulance company interests and patient interests. Ideally patient interest should hold the most value as they are the users of the system. Moreover, the livelihood of people is at stake here so there is an ethical responsibility to make sure the patients' interests are incorporated. The four factors that could affect ambulance delivery systems are outlined in Figure 3 on page 6.

COMPANIES, GOVERNMENT, BIAS, AND PATIENTS

As businesses, air ambulance companies seek to make as much profit as they can (McDonough, 2019, n.p.). While they have an ethical responsibility to the public, they do not take this into account. Patients are rarely considered when making decision. The government is also very hands-off when it comes to businesses, so there is very little regulation to protect patients. In fact, the 1978 Airline Deregulation Act benefited air ambulance companies. It prohibited state governments from regulating price, route, or service of air carriers, which includes air ambulances. Perhaps, this was an unintended consequence of the act but the government has done very little since then to regulate air ambulance or protect patients. In some places, the government has tried to create their own air ambulance delivery system but they are not able to hold their own in an industry dominated by private systems (Shaw, 2020, n.p.). The private air ambulance systems have become so big that it is very difficult to dismantle them without regulation.

BIASES OF TECHNOLOGY CREATORS

Finding the specific biases of the technology creators is very difficult, as this information is largely hidden. Since private companies are creating these technologies, some confidentiality agreements are probably in place, making it difficult to see the people involved in the creation of ambulance delivery technology. However, it is known that technology creators do input their

own biases into the technologies they create (Walsh & Kirchhoff, 2002, n.p.). Therefore, when creating new technology in the future this fact should be considered and efforts should be made to identify bias and reduce it when possible.

WHAT CAN BE DONE?

Over time, the main interests that have affected the development of ambulance delivery technology are those of the ambulance companies. More recently, the government has been intervening to regulate ambulance companies in order to provide more benefits to patients. An example of this is when the No Surprise Act was passed (Kliff & Sanger-Katz, 2020, n.p.). The Act contained a clause that outlawed balance billing for air ambulances. Balance billing is the process of billing patients the difference between in-network and out-of-network costs, when out-of-network services are used. However, for air ambulances and some other services, it is close to impossible to choose an in-network provider so the high bills usually come as a surprise. The No Surprise Act, which will go into effect in 2022, will be one of the first times that the government sided with patients against air ambulances. The government has started to regulate some of the air ambulance companies which is a step in the right direction towards equal access. However, ground ambulances are not included in the act, so balance billing and surprise bills can still occur for ambulances, showing that the system is nowhere near perfect in achieving proper access to healthcare. Government regulation is needed to reduce the current biases in the ambulance and emergency medical services systems.

Companies have a nature of wanting to mainly consider profits. The responsibility is then on the government to ensure that the consumers' interests are also considered, especially in the public health sector, where patients' lives are at risk. Systemic changes are needed to have a

real impact on the current healthcare disparities. These changes should include the incorporation of less biased technologies that benefit (or at least do not harm) the patient.

In order to develop less biased technology, the biases involved in the creation of existing ambulance dispatch technologies must be thoroughly analyzed and research. Without proper research, the biases will be present in future technology as well. The same mistakes will keep occurring. The only way to prevent that is to perform research on existing technologies to fully understand their impact. From there, new less biased technology can be properly developed.

WORK CITED

- Ardhapurkar, N. (2020). *Factors that affect ambulance delivery systems*. [Figure 4]. *Prospectus* (Unpublished undergraduate thesis). School of Engineering and Applied Science, University of Virginia. Charlottesville, VA.
- Arias, E., Tejada-Vera, B., & Ahmad, F. (2021, February). *Provisional life expectancy estimates for January through June, 2020*. Retrieved from <https://www.cdc.gov/nchs/data/vsrr/VSRR10-508.pdf>
- Centers for Medicare and Medicaid Services. (2019). *National Health Expenditures 2018 Highlights*. CMS. Retrieved from <https://www.cms.gov/files/document/highlights.pdf>
- Hinsdale, J. G. (2018). *Air Ambulance Regulations and Payments* (Report to CMS No. 2-I-18; Report of the Council on Medical Service, p. 6). American Medical Association.
- Hsia, R. Y., Huang, D., Mann, N. C., Colwell, C., Mercer, M. P., Dai, M., & Niedzwiecki, M. J. (2018). A US national study of the association between income and ambulance response time in cardiac arrest. *JAMA Network Open*, *1*(7), e185202. doi:<https://doi.org/10.1001/jamanetworkopen.2018.5202>
- Hsia, R. Y.-J., Asch, S. M., Weiss, R. E., Zingmond, D., Liang, L.-J., Han, W., McCreath, H., & Sun, B. C. (2012). California hospitals serving large minority populations were more likely than others to employ ambulance diversion. *Health Affairs*, *31*(8), 1767–1776. doi:<https://doi.org/10.1377/hlthaff.2011.1020>
- Institute of Medicine (2011). *Preparedness and Response to a Rural Mass Casualty Incident* (1st digital ed.). The National Academies Press. doi: 10.17226/13070.
- Jarman, M. P., Castillo, R. C., Carlini, A. R., Kodadek, L. M., & Haider, A. H. (2016). Rural risk: Geographic disparities in trauma mortality. *Surgery*, *160*(6), 1551–1559. doi:<https://doi.org/10.1016/j.surg.2016.06.020>
- Kliff, S. & Sanger-Katz, M. (2020, December 20). Surprise medical bills cost Americans millions. Congress finally banned most of them. *New York Times*. Retrieved from <http://www.nytimes.com/>
- McCausland, P. (2019, September 6). Rural hospital closings cause mortality rates to rise, study finds. *NBC News*. Retrieved from <https://www.nbcnews.com/>

- McDonough, J. E. (2019). Shareholders, stakeholders, and US health care. *The Milbank Quarterly*, 97(4), 918–921. doi:<https://doi.org/10.1111/1468-0009.12432>
- MedPac. (2013, June). *Mandated report: Medicare payment for ambulance services*. Retrieved from <http://www.medpac.gov/docs/default-source/reports/chapter-7-mandated-report-medicare-payment-for-ambulance-services-june-2013-report-.pdf?sfvrsn=0>
- Pinch, T. J. & Bijker, W. (1987). The Social construction of facts and artifacts. In *The Social construction of technological systems: New directions in the sociology and history of technology*. Cambridge, MA: MIT Press.
- Rogers, F. B., Rittenhouse, K. & Gross, B. W. (2014). The golden hour in trauma: Dogma or medical folklore? *The Journal of Lancaster General Hospital*, 9(1), 11-13. doi:<https://doi.org/10.1016/j.injury.2014.08.043>
- Shaw, C. M. (2020, March 23). *Emergency of Expanding Government*. The New American. Retrieved from <https://thenewamerican.com/print/emergency-of-expanding-government/>
- Simms, M. C., Fortuny, K. & Henderson, E. (2009, August). *Racial and ethnic disparities among low-income families*. Retrieved from <https://www.urban.org/sites/default/files/publication/32976/411936-racial-and-ethnic-disparities-among-low-income-families.pdf>
- Suryanto, Plummer, V., & Boyle, M. (2017). EMS Systems in lower-middle income countries: A Literature Review. *Prehospital and Disaster Medicine*, 32(1), 64–70. doi:<https://doi.org/10.1017/S1049023X1600114X>
- The Association of Air Medical Services. (2019). *Atlas and Database of Air Medical Services*. CUBRC, Public Safety and Transportation Group. http://www.adamsairmed.org/pubs/atlas_2019.pdf
- United States Government Accountability Office. (2019). *Air Ambulance: Available Data Show Privately-Insured Patients Are at Financial Risk* (GAO-19-292; Report to Congressional Committee). United States Government Accountability Office. Retrieved from <https://www.gao.gov/assets/700/697684.pdf>
- Walsh, S. T., & Kirchoff, B. A. (2002). Technology transfer from government labs to entrepreneurs. *Journal of Enterprising Culture*, 10(2), 133-149. doi: <https://doi.org/10.1142/S0218495802000177>

Wong, H. T., Lin, T.-K., & Lin, J.-J. (2019). Identifying rural–urban differences in the predictors of emergency ambulance service demand and misuse. *Journal of the Formosan Medical Association*, *118*(1, Part 2), 324–331. doi:<https://doi.org/10.1016/j.jfma.2018.05.013>