

Optimizing Surgical Planning for Patellar Instability Pathologies

(Technical Paper)

The Flaws within the United States Healthcare System that Create Economic Burdens

(STS Research Paper)

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On my honor as a University Student, I have neither given nor received Unauthorized aid ont his
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Introduction to United States Healthcare

The United States healthcare system falls far from perfect; It is known for creating massive amounts of debt and failing to provide equal care. The United States of America's (U.S.) debt is growing by the second and the largest contributor to that is healthcare spending. Healthcare debt differs from other forms of debt, such as credit card or mortgage debt, as an individual does not have complete autonomy over their health and preventative options. With over \$140 billion dollars in unpaid medical bills in 2020, the U.S. healthcare debt has more than doubled from 2016, which was at \$81 billion (Kliff & Sanger-Katz, 2021). This debt only includes the ones sold to collection agencies; it does not factor in costs from the COVID-19 pandemic, and therefore gravely underestimates the actual total healthcare debt (Abrams, 2020).

Medicaid and medicare are two federally and state funded programs that are in place to help insure elderly and impoverished persons. However, there are large inequalities embedded within the U.S. healthcare system. Low and middle income citizens struggle to get quality care. Minority groups are often met with discrimination in medical clinics, resulting in care below the standard of care treatment. The vast amount of uninsured citizens costs the American people over \$120 billion annually (Chemweno, 2021). With no universal healthcare, the U.S. healthcare system is mainly privatized, with 56% of Americans receiving insurance coverage from private insurance (Johns Hopkins University, 2012). Another 27% of citizens receive their coverage from public insurers and 16% completely lack coverage (Duckett, 2020). America is one of the leading countries in biomedical research, yet has one of the lowest life expectancy out of the OECD countries. The events of COVID-19 shed light on U.S. healthcare disparities, including the monetary burden the system creates.

In this paper, it will be discuss how various forms of healthcare, including long-term healthcare, emergency room visits, and medical technology, all contribute to the economic burden created by the United States' medical system. Actor-network theory (ANT) will be used

to analyze how key actors in the United States healthcare network create an unstable network. ANT is appropriate for this analysis because it considers both the human and nonhuman actors in an already existing network. Micro-level studies are used at the creation of technology, following all the actors and network builders (Cressman, 2009). Key actors in this network are the United States government, insurance companies, patients, physicians, medical diseases/injuries and engineers.

Factors that Create Economic Burden within the United States Healthcare System

Long-term Healthcare

_____ The United States healthcare debt crisis is exacerbated by long-term patients. Among the most recognized and affected long-term patients are cancer patients. There are 12 million people in the U.S. that have a history of cancer and with an aging population, this count is expected to rise (Yabroff et al., 2011). Long-term cancer treatment results in the loss of financial resources for the patient, family caregivers, and employers. Costs overtime follow a U-Shaped curve, with higher costs once diagnosed with cancer and end of life costs for terminal patients (Figure 1) (Yabroff et al., 2011).

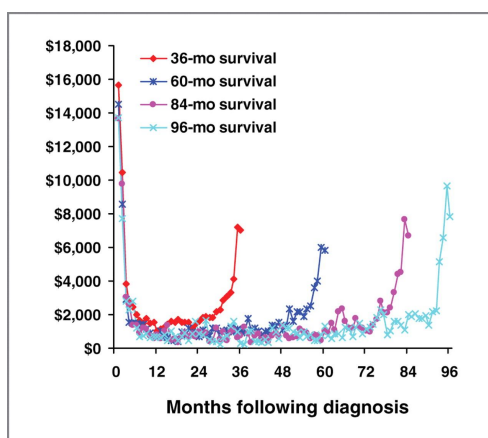


Figure 1: Monthly costs of care for colorectal cancer patients by length of survival (Yabroff et al., 2011).

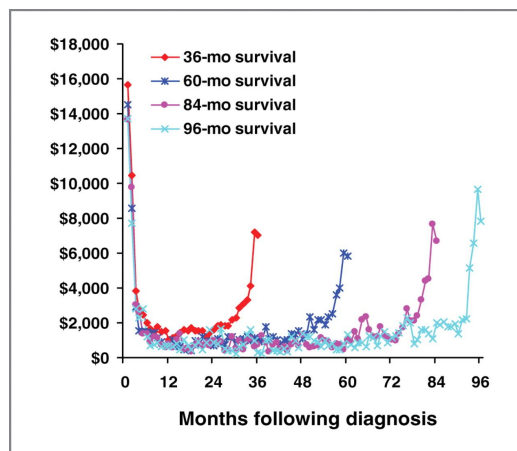
Direct costs vary drastically for the different types of cancers. Female breast cancer has an average monthly net cost of \$1,923, while female lung cancer can range up to \$5,074, with prices increasing during end-of-life care. These costs include hospitalization, surgery, check up visits, various types of therapy, and insurance costs. Out-of-pocket costs also tend to be higher for cancer patients. These costs typically increase for long-term patients; many patients lose employee sponsored health insurance if they are forced to take a leave of absence from work to focus on their treatment. Individuals on medicare that have cancer also pay a yearly extra average of \$976 dollars when compared to those that are cancer free (Richard et al., 2021; (Yabroff et al., 2011). A study conducted by Yabroff et al. looked at cancer prevalence cost, which are defined as phase-specific cost estimates that can be combined with phase-specific prevalence estimates obtained from incidence and annual survival data. These costs were estimated to be \$124 billion in 2010 (Yabroff et al., 2011). The costs also varied with the type of cancer, with the highest costs in breast and prostate cancer, the two forms of cancer with the longest treatment length.

Indirect costs also greatly contribute to long-term healthcare burdens. These costs include monetary losses associated with time spent receiving care, time lost from work or other regular activities (known as morbidity costs), and loss of productivity due to a premature death (known as mortality costs). Human capital modeling was used to estimate mortality costs to be \$115.8 billion (Yabroff et al., 2011). This approach uses gender and age-specific average earnings and is combined with time lost from work due to premature death. Willingness-to-Pay modeling was also used to estimate mortality costs in the year 2000, and was found to be \$960.6 billion (Yabroff et al., 2011). Willingness-to-Pay incorporates both lost productivity and the intrinsic value of life, by estimating the amount on average an individual would be willing to pay for an additional year of life. The unrealistic high cost of long-term treatment has caused financially insecure patients to delay their treatment, thus worsening their condition. With new

drug therapies and treatments being developed every year, costs will continue to increase (Richard et al., 2021).

Along with cancer, Alzheimer's is at the top of long-term healthcare spending. In 2013, it passed cancer and became the most expensive disease in America. Alzheimer's is estimated to cost \$355 billion by the end of 2021 and increase to \$1.1 trillion by 2050 (Preidt, 2018). Over 6 million Americans are currently diagnosed with Alzheimer's, the majority being individuals over the age of 65.

New drug therapies have contributed to the rise of medical costs for Alzheimer's patients, one particular drug is aduhelm. Aduhelm was recently FDA approved this past year and is known as "the drug that may break the healthcare system" (Lagasse, 2021). It costs nearly \$60,000 per year for aduhelm; with additional hospital fees, such as MRI scans and IV materis, an Alzheimer's patient's yearly total cost can add up to \$100,000. Since most Alzheimer patients are either on Medicare or Medicaid, it is costing federal and state governments millions of dollars annually to subsidize Alzheimer's treatment. If 25% of all Alzheimer's patients were prescribed Aduhelm, it would increase state medicaid spending by



\$230 million and federal spending by \$490 million (Dolan, 2021). The many actors involved in long-term patient care, including the disease itself, the patient, hospital staff, pharmaceutical companies, and government healthcare policies, have failed to create a stable network for the

patients, resulting in long-term economic burden on individuals and for state and federal economies.

Emergency Room Costs

Emergency room (ER) visits are among the greatest concerns for healthcare costs. With 27 million ER visits annually in the United States, the total national healthcare cost amounts to \$32 billion (Williams, 2019). ER visits are unplanned and unpredictable in their final costs. When arriving at an American ER, your condition is given a rating on a scale of one to five. A rating of one gives you immediate attention, while a five is redirected to a non-emergency facility, with most cases given a rating somewhere in between a one and five (Corso, 2021). The average medical bill from the ER is around \$2,200, which will encompass triage fees, facility fees, professional fees, and supplies. These charges vary greatly depending on the injury/condition present. For example, the average cost to treat bronchitis is \$814, while a sore throat is \$620. Cost also varies greatly based on the state you are in. Maryland has the lowest average ER cost at \$623, while Florida has the greatest at \$3,102 (Corso, 2021). ER costs are a major factor limiting people who do not seek out care until it is medically necessary. This causes cases to worsen and when medical care is finally sought out it ironically increases the patient's bill (Miller, 2012). Unforeseen injury or disease are rogue actors within this network. They cause disruption within the healthcare system and add to an increasing debt.

Insurance costs are also a major factor that contribute to ER overload and increased costs. A case study on the 2006 Massachusetts healthcare reform legislation analyzed the effects of insurance coverage on ER visits. In 2006, Massachusetts passed legislation mandating that all state residents must have insurance, or they would have to pay a non-compliance fee (Miller, 2012). Free and subsidized insurance were made more accessible for low and middle income residents, with programs such as MassHealth and Commonwealth Care being rolled out. MassHealth expanded eligibility for low-income individuals and children, and

removed caseload caps on residents with disabilities, persons with HIV, and long-term unemployed persons. Commonwealth Care providers publicly subsidized insurance to individuals who are not eligible for employer-provided coverage or MassHealth and earn up to 300% of the federal poverty line income. Before the reform, 80% of all ER cases in Massachusetts did not lead to hospital admissions, with 18% classified as non urgent and 16% classified as primary care treatable (Miller, 2012). However, many uninsured individuals seek out ER treatment rather than primary care due to the legal obligation to treat you in the ER. This overuse of the ER is one factor that contributes to the large sum of money spent on healthcare in the United States. ER costs outweigh primary care costs even when given the same care.

After the Massachusetts reform it was estimated that a 1% increase in insurance coverage predicts a reduction in ER use by 0.5 visitors per 100 residents (Miller, 2012). There was also a sizable reduction in ER visits for cases that could be treated by primary care providers, with most of these cases observed to occur during the weekday. This supports an argument to increase medical student enrolment in primary care to increase accessibility (Williams, 2019). Seeking primary care also increased the quality of care for individuals as it allowed for access to specialized doctors that may not be present in the ER (Miller, 2012). This case study highlights the unstable network created by government healthcare legislation and insurance companies. The Affordable Care Act has helped to address some of the economic flaws of this network, but there are still barriers to receiving quality healthcare.

Medical Technology

Medical technology can not be directly correlated to the increase in healthcare spending. However, by subtracting the costs we can directly link to healthcare spending it is clear that new medical technology can be attributed as a main cause of increased healthcare spending (Kumar, 2011). There has been a trend nationwide to incorporate technology into all aspects of

healthcare. This incorporation of technology has created a dependency on diagnostic and information technology, thus creating more barriers and making healthcare more inaccessible.

There has been a focus in the medical device field to make technology more sophisticated, with a focus on increasing accuracy and adding new features to medical technology. This emphasis on advancing medical technology has taken the place of increasing accessibility. Echocardiograms are an example of medical technology that has increased in complexity and decreased in accessibility (Kumar, 2011). An echocardiogram uses high energy sound waves, known as ultrasound, to look at tissues and organs within the chest. Since being first created, echocardiograms have evolved to include 3D imaging in real time and additional diagnostic measurements. These features provide very little additive information when making a diagnostic when compared to simpler, miniaturized versions of the machine (Maida, 2021; Kumar, 2011).

Consumers of medical technology do not use the products, but have the products used on them. They are also given little say in which products should be used and are usually uninformed about the diagnostic equipment used. Since there are only a few worldwide competitors for echocardiograms, companies can focus on making the technology more sophisticated, driving the price up and further adding to healthcare disparities (Kumar, 2011). Large corporations have the ability to create artificial demand for their products and export this for profit (Maida, 2021). Medical business and investors revenue equivalent to \$70-\$90 billion per year (HealthCare & Gray, 1986). Engineers are key actors in creating new medical technology and contribute to the unstable network by creating new, unnecessary economic burdens. Engineers must consider the downstream effects of their designs and strive to create accessible technology to all.

Ethics of Creating New Medical Technology

A key question raised in this discussion is whether healthcare is an economic good. The current actors within the healthcare network currently treat it as one, putting monetary values on life saving services. There is a need for cost-effective interventions within the healthcare system. With an aging population and continuous technological advancements, the cost of living is increasing. An average increase of 3.5% in healthcare spending per year, correlated to nearly a \$2 trillion increase in annual healthcare spending (Goyen & Debatin, 2009). Leading experts in this field agree that a one-half to one-third of this spending can be attributed to medical technology innovation (Goyen & Debatin, 2009). As crucial actors in the healthcare network, do engineers have an ethical obligation to halt the creation of new technology to spare consumer debt?

Some technologies do have the possibility of reducing medical spending. For example, vaccines have shown to increase short-term medical spending, but reduce long-term spending by preventing the progression of a disease (Goyen & Debatin, 2009). However, many advancements to medical technology come from minor alterations to existing technology. With \$111 billion being spent on medicine, is the United States spending their money wisely? From 1960 to 2000 there was a 7 year increase in life expectancy. Leading experts have attributed 3.5 years of this increase to advancements in medical technology, this correlates to one extra year of life equivalent to \$19,900. The worth of yearly life is estimated to be \$50,000 - \$200,000 (Goyen & Debatin, 2009). According to these numbers the investment in medical technology has been worth it. However, this raises the question on whether the strain caused on personal and government budgets is worth it? When new technology is adopted, there is no streamline process to assess its value. To effectively integrate new technology, key actors must be held accountable and lower the economic barriers to receive healthcare.

Conclusion

Anyone who has gotten sick or injured can understand how frustrating the U.S. healthcare system can be. What might not be so obvious is the economic inaccessibility and burden created by this system. An analysis utilizing actor-network theory shows the key actors within the healthcare network and elucidates how these actors have created an unstable network. Long-term healthcare and ER visits are among the greatest contributors to U.S. healthcare debt. Key actors, such as the U.S. government, engineers, and insurance companies, fail to create a stable network and fail to provide accessible, affordable medical care. Medical technology is also a primary factor in increased medical spending which leads to further debt. As engineers, we have to evaluate our role in the network and consider the ethics of creating new technologies and the monetary consequences of doing so.

References

- Abrams, A. (2020, January 6). *The U.S. Spends \$2,500 Per Person on Health Care Administrative Costs. Canada Spends \$550. Here's Why.* Time.
<https://time.com/5759972/health-care-administrative-costs/>
- Chemweno, J. (2021, July 27). *The U.S. Healthcare System is Broken: A National Perspective.* Managed Healthcare Executive.
<https://www.managedhealthcareexecutive.com/view/the-u-s-healthcare-system-is-broken-a-national-perspective>
- Corso, A. (2021, September 17). *How Much an ER Visit Costs Without Insurance in 2021 | Mira.*
<https://www.talktomira.com/post/how-much-does-an-er-visit-cost>
- Cressman, D. (2009). *A Brief Overview of Actor-Network Theory: Punctualization, Heterogeneous Engineering & Translation.* <https://summit.sfu.ca/item/13593>
- Dolan, R. (2021, July 13). *How Might the FDA's Approval of a New Alzheimer's Drug Impact Medicaid? KFF.*
<https://www.kff.org/medicaid/issue-brief/how-might-the-fdas-approval-of-a-new-alzheimer-s-drug-impact-medicaid/>
- Duckett, S. (2020, November 18). *How the US health-care system works—And how its failures are worsening the pandemic.* The Conversation.
<http://theconversation.com/how-the-us-health-care-system-works-and-how-its-failures-are-worsening-the-pandemic-150271>
- Goyen, M., & Debatin, J. F. (2009). Healthcare costs for new technologies. *European Journal of Nuclear Medicine and Molecular Imaging*, 36(1), 139–143.
<https://doi.org/10.1007/s00259-008-0975-y>
- HealthCare, I. of M. (US) C. on I. of F.-P. E. in, & Gray, B. H. (1986). Profits and Health Care: An Introduction to the Issues. In *For-Profit Enterprise in Health Care*. National Academies Press (US). <https://www.ncbi.nlm.nih.gov/books/NBK217897/>

- Johns Hopkins University. (2012, March 8). Structure of the U.S. Health Care System. *AICGS*.
<https://www.aicgs.org/2012/03/structure-of-the-u-s-health-care-system/>
- Kliff, S., & Sanger-Katz, M. (2021, July 20). Americans' Medical Debts Are Bigger Than Was Known, Totaling \$140 Billion. *The New York Times*.
<https://www.nytimes.com/2021/07/20/upshot/medical-debt-americans-medicaid.html>
- Kumar, R. K. (2011). Technology and healthcare costs. *Annals of Pediatric Cardiology*, 4(1), 84–86. <https://doi.org/10.4103/0974-2069.79634>
- Lagasse, J. (2021, July 14). *New Alzheimer's drug could cost Medicaid more than \$2 billion*. Healthcare Finance News.
<https://www.healthcarefinancenews.com/news/new-alzheimers-drug-could-cost-medicaid-more-2-billion>
- Maida, J. (2021, April 27). *Top 6 Vendors in the Global Echocardiography Devices Market From 2017-2021: Technavio*.
<https://www.businesswire.com/news/home/20170427006561/en/Top-6-Vendors-in-the-Global-Echocardiography-Devices-Market-From-2017-2021-Technavio>
- Miller, S. (2012). The effect of insurance on emergency room visits: An analysis of the 2006 Massachusetts health reform. *Journal of Public Economics*, 96(11), 893–908.
<https://doi.org/10.1016/j.jpubeco.2012.07.004>
- Preidt, R. (2018, March 20). *Alzheimer's costs Americans \$277 billion a year—And rising*.
<https://www.cbsnews.com/news/alzheimers-costs-americans-277-billion-a-year-report/>
- Richard, P., Patel, N., Lu, Y.-C., Walker, R., & Younis, M. (2021). The Financial Burden of Cancer on Families in the United States. *International Journal of Environmental Research and Public Health*, 18(7), 3790. <https://doi.org/10.3390/ijerph18073790>
- Williams, J. (2019, July 22). *'Avoidable' ER Visits Fuel U.S. Health Care Costs | Health News | US News*.
<https://www.usnews.com/news/health-news/articles/2019-07-22/avoidable-er-visits-fuel-u>

s-health-care-costs

Yabroff, K. R., Lund, J., Kepka, D., & Mariotto, A. (2011). Economic Burden of Cancer in the United States: Estimates, Projections, and Future Research. *Cancer Epidemiology and Prevention Biomarkers*, 20(10), 2006–2014.

<https://doi.org/10.1158/1055-9965.EPI-11-0650>