Longitudinal Insights for People with Type I Diabetes
(Technical Topic)

The Role of Systemic Structures in Diabetes Technology Disparities
(STS Topic)

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

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Introduction:

Diabetes is one of the most common diseases in the world, affecting around 10% of the world's population. If the current trends regarding access to healthcare and resources to manage diabetes persist, it is projected that the number of people with diabetes will rise by 46% by 2045, potentially affecting around 250 million more people globally (International Diabetes Federation, 2023).

Diabetes exists in two major forms, type II and type I diabetes (World Health Organization, 2023). My research focuses on Type I Diabetes (T1D), which is a chronic condition that occurs when the pancreas does not create enough or any insulin, a hormone used to control blood glucose levels. T1D patients experience a build up of glucose in the bloodstream, which has a myriad of side effects across a range of severity (Walker et.al, 2015, p. 62-29).

There are several devices that T1D patients use to manage their condition, including insulin pumps/pens, blood glucose monitors (BGM), continuous glucose monitors (CGM), or automated insulin dosing (AID) systems. These devices are essential to the daily management of the disease and allow patients to keep track of their blood glucose and/or insulin levels in different ways. BGMs and insulin pens require the patient to manually check their blood glucose and insulin levels, respectively, whereas other devices automatically keep track of and/or dispense medication. There are also several diabetes data management platforms that allow patients and providers to upload data from their devices and track changes in crucial biometrics. (American Diabetes Association).

Regardless of the advancements in diabetes technologies, socioeconomic standing plays a large role in how individuals experience T1D. Diabetes causes a significant economic burden on patients, with a total $412.9 billion spent on diabetes by diagnosed patients in the United States. Diabetes patients spend an average of $19,736 on an annual basis and thereby spend around 2.5 times more money on medical expenses than the average American (Parker et al., 2022, p. 32-33). To help navigate these costs, patients enroll in insurance plans to mitigate some of these costs, however patients of lower socioeconomic standing have limited access to insurance plans that can fully support their needs, and thereby limited access to diabetes devices that will help them navigate their condition (Scott et al., 2017, p. 11-14). These disparities indicate a dire need to improve access to effective treatment and resources for diabetes management, especially for patients of lower socioeconomic status.

For my technical project, I will work to redesign a diabetes data management platform and work to create more intuitive insights within this platform. I will be partnering with Tidepool, a non-profit diabetes platform that manages data from a variety of different diabetes management devices to help patients and providers further understand the status of their condition. In my STS project, I will address the disparities in the access to diabetes devices, by exploring the current insurance landscape in the United States. I hope to understand how insurance offerings in this landscape support T1D patients across demographics, as well as how these dynamics exacerbate current inequities in the T1D space. Expanding upon these findings, I will look into the potential effects of continuing to operate the insurance landscape in the current state on T1D patients and the American healthcare system. Connecting my technical and STS projects together, I hope to contextualize the work I am doing to improve a diabetes data management platform with a deeper understanding of the systemic barriers faced by T1D patients, ensuring that technological advancements are designed to address inequities and promote accessibility across diverse patient populations.

Technical Topic:

Patients living with type I diabetes usually use at least one diabetes device, if not multiple, to help them manage their condition. Most of the time, these devices have associated data platforms that allow users to look at the health metrics that the device is collecting, as well as simple trends and analyses of the patient's data, which encourages patients to react to these immediate trends. Health care providers (HCPs) play a critical role in analyzing the patient's data, however they are limited by the time and resources that it takes to download, review, and interpret this data during the patient's visit. Because of this, HCPs have struggled with how they should discuss the data with their patients and may deter patients from using devices that collect more data, like continuous glucose monitors, due to the complexity of the analysis required to fully understand data from these devices. Furthermore, patients' visits with HCPs are infrequent in comparison to the amount of times patients could benefit from receiving insights on their diabetes data. For type I diabetes patients to use diabetes data on their own, patients need a platform that syncs data from multiple devices and provides insights in an automated manner (Wong et al., 2018, p. 806-816).

For my technical project, my team will be working with Tidepool, a diabetes data management platform, where patients can log meals, site changes, and other important details, as well as upload data from multiple diabetes management devices. Currently, Tidepool incorporates data across multiple devices and presents analyses of a patient's diabetes data over an extended period of time (Tidepool, n.d.). Our goal is to enhance Tidepool's platform by optimizing existing features and incorporating novel advanced features that will provide longitudinal insights to patients and providers. We aim to equip users with easy-to-understand data visualizations, prompts and suggestions to help them improve their condition, and offer spaces for reflection and goal-setting, empowering patients to take control of their diabetes.

Currently, the Tidepool platform incorporates information from a variety of devices across vendors, including BGMs, CGMs, insulin pumps, and AID systems, and presents the trends in the biometrics coming from these devices. Users have commented about the abundance of data that is presented on the platform, noting that it is hard for patients and healthcare providers to view this data and draw insights and conclusions from it (Iyengar et al., 2016, p. 5).

With these comments and developments in mind, our project centers around two opportunities for expansion. One of these opportunities centers around developing an algorithm to detect and display variations in a patient's biometric data on both daily and weekly scales and identify times of the day and week where the patient's blood glucose levels are in extreme zones. Using previous literature, we will identify health and behavioral trends that are associated with the times that are indicated through the analysis and develop prompts to be presented to the patient that encourage them to consider these factors. From there, we will redesign graphs and visualizations that clearly indicate the identified fluctuations in the patient's diabetes device data and allow the patient to clearly understand long-term historical changes in the status of their condition.

The second opportunity focuses on developing a 5-minute summary feature that synthesizes the patient's health history from the previous month and presents the results and suggestions for the patient in a clear and easy-to-understand format for patients and providers. We will use Python to analyze the data from the patient's diabetes device and identify overarching trends in the previous month's data to further compare these trends to the patient's historical data. Using the trends from the prior month, we will identify areas of improvement and provide suggestions for the patient to change their behavior/dosing/etc. based on the most pertinent factor(s) identified. Lastly, we will develop an interactive summary feature that will allow the patient an opportunity to reflect on the previous month and set goals for the future.

To measure the success of our solution, we plan on beta-testing the new version of the platform with current users and receive their feedback on the features that we develop, adjusting our code and design accordingly. With the development of the features on the Tidepool platform, we hope that patients will better understand how their condition has changed over time and feel empowered to improve upon their condition using the analyses and suggestions offered in the future-state platform.

STS Topic:

The management of type I diabetes is an involved, ongoing process that patients, parents, or caretakers have to engage in. The monitoring of blood glucose (BG) levels throughout the day and administration of insulin to combat high BG levels requires the use of diabetes devices to accurately indicate these times of vigilance. For example, to comply with American Diabetes Association standards, type I diabetes patients must self-monitor their blood glucose levels at least 3-4 times a day, if not more, to ensure that their glycemic targets are being reached (Kahanovitz et. al, 2017, p 37-40). To self-monitor their blood glucose levels, patients usually use one of two devices: blood glucose monitors or continuous glucose monitors. Blood glucose monitors (BGMs) use a blood sample that patients will usually draw from the tip of their finger to produce a reading on the patient's blood glucose levels. Continuous glucose monitors (CGMs) are inserted into the subcutaneous layer of the skin, producing readings on a patient's blood glucose levels every 5-10 minutes (Patton & Clements, 2012, p 27-29). This allows the patients to capture trends in their blood glucose levels and set alerts for hypo- or hyper-glycemic events. In response to high BG readings taken by BGMs or CGMs, patients or caretakers will administer insulin to combat these high blood glucose levels through insulin injections or insulin pumps. T1D patients using insulin pumps have shown to have more stable and lower blood glucose levels as compared to patients using insulin injections (Pickup, 2002, p. 705). With this context, it is imperative that T1D patients have access to continuous glucose monitors and insulin pumps for the proper management of their condition.

While T1D patients require these devices for the proper management of their condition, continuous glucose monitors and insulin pumps are expensive, with CGM prices ranging from \$2000-\$7000 per year, without insurance (Watson, 2022). Insulin pumps cost around \$6000 per year without insurance, with an additional \$3000-\$6000 required for other supplies associated with the insulin pump (Khan, 2022). The price tags on these devices indicate a need for type I diabetes patients to have an insurance plan to help shoulder the economic burden of the cost of these tools. 92% of adults with diabetes have some form of insurance, meaning that around 600,000 diabetes patients don't have any coverage and are forced to pay out-of-pocket for any diabetes management tools, indicating a substantial disparity in the access to insurance. A lack of insurance was associated with lower socioeconomic standing (Harris et. al, 1994, p. 585-591). Furthermore, higher socioeconomic status and more generous/private insurance plans allowed for higher usage of CGMs and insulin pumps within T1D patients. The use of CGMs and insulin pumps were associated with fewer adverse effects of type I diabetes, showing an indirect association between socioeconomic status and insurance coverage with the adverse effects associated with these diabetes devices. The socioeconomic disparities in access to these crucial diabetes technologies increase the risk of adverse effects, including severe hypoglycemia and diabetic ketoacidosis, in patients of lower socioeconomic standings, as well as patients using public insurance plans (Everett & Wisk, 2022, p. 825-833).

As indicated above, the inequalities in access to diabetes technologies are significant, with insurance offerings playing a major role in the ability for patients to access continuous glucose monitors and insulin pumps. In order to address these inequalities in diabetes technology access, we must analyze the current landscape of insurance offerings and how they align with accessibility issues regarding diabetes technologies in the type I diabetes space. In this STS research project, I plan on investigating the insurance offerings within the type I diabetes space across a span of public and private offerings, as well as the associated healthcare policies that govern how patients of different socioeconomic standing can interact with this insurance landscape. From there, I hope to better understand how insurance offerings and associated healthcare policies amplify disparities in access to CGMs and insulin pumps, as well as the potential implications of continuing to maintain this insurance landscape on patients and the larger US healthcare system. I hope this research will inform policy recommendations and contribute to the development of more equitable insurance models that prioritize accessibility to essential diabetes technologies. By shedding light on the systemic barriers faced by T1D patients and the potential implications of the current insurance landscape, I hope that the information provided in this thesis paper will provide actionable insights for insurance companies and policymakers to reduce disparities and improve health outcomes for underserved type I diabetes patients.

I will use two sociotechnical frameworks to analyze the current insurance landscape for type I diabetes and speculate the continued impacts of this landscape on patients and the larger healthcare system. The first is the **political economy of health** framework, which concerns how political and economic domains interact and shape individual and larger population health outcomes. The framework first outlines how politics and the economy are inherently tied together, with politics creating and shaping the economy and vice versa. Diving into the healthcare context, the framework considers the manner with which societies choose to produce and distribute resources across a population as an important determinant in population health (Harvey, 2021, p. 293-300). Specifically, Krieger writes that the basis of the political economy of health theory is the hypothesis that political and economic institutions that perpetuate social privileges and inequalities are the fundamental causes for any social inequalities in health (Krieger, 2021, p. 668-677). In my research, I will use this framework to understand and contextualize how current healthcare and insurance policies privilege certain social groups, while simultaneously creating disadvantages for other social groups. This framework will also be used to look at the effects of current insurance policies on patients and the larger American healthcare system. The second framework I will use for my analysis is the **risk society theory**, devised by sociologist Ulrich Beck. In his work, Beck defines social risks as responses to issues that have come about as a result of modernization. His larger theory postulates that societies focus increasingly on dealing with the risks that are unintended consequences of industrial and technological advancements and the risks that arise are due to human decisions, actions, and structures (Pritchard, 2015, p. 396-400). In the context of healthcare, risk society theory has been used to analyze the COVID-19 epidemic and the social factors that led to the global spread of the disease (Mansouri & Sefidgarbaei, 2021, p. 36-37). In my project, I plan to use risk society theory to analyze the human-manufactured risks that create inequities in access to diabetes technologies, such as continuous glucose monitors and insulin pumps, arising from systemic decisions within the insurance industry and healthcare policy. This framework will also allow me to predict the potential implications of maintaining the current insurance landscape, including worsening health outcomes for underserved patients and increasing strain on the broader American healthcare system.

To dive deeper into my research methods, first, I will use two overview articles to gain a better understanding of the American healthcare system (Lew et. al, 1992; Chapin, 2010). I also hope to look into the overarching healthcare policies that impact the insurance offerings in the American healthcare system (Koltz et. al, 2013, p. 692-693), as well as specific healthcare policies that impact insurance offerings that offer diabetes support (Hill, 2013, p. 67-72). From there, I plan on conducting multiple case studies on how insurance support is offered to type I diabetes patients across private and public offerings. Specifically, I will look into criteria to enroll in the insurance plans, criteria to receive insurance support for purchasing continuous glucose monitors and insulin pumps, as well as the associated costs and fees, using the information on the website for the insurance plan. This information will further inform the disparities and access issues in regards to obtaining CGMs and insulin pumps, that I will analyze using the political economy of health and risk society frameworks. I also hope to gather information about the policy changes that have affected diabetes accessibility (Pathak et. al, 2022, p. 169-177) to further understand the political factors affecting accessibility in the diabetes space. Next, I plan to better understand the potential implications of continuing to operate with the current insurance landscape by understanding the financial burden that living with type I diabetes has on individual patients, as well as the economic burden on the larger American healthcare system (Tao et. al, 2010, p. 1-11). Lastly, I hope to conduct interviews with diabetes patients that use CGMs and insulin pumps, using contacts at Tidepool, to better understand the impact of their insurance plans on how they navigate their diabetes and obtaining their diabetes devices. Hopefully by conducting these analyses and interviews, I will be able to to understand the current insurance landscape as it pertains to type I diabetes and postulate the potential implications on continuing to function in this current-state landscape.

Conclusion:

As disparities in access to diabetes technologies persist and the insurance landscape remains a critical determinant of care, it is essential to critically examine how the current system impacts patients with Type 1 Diabetes across socioeconomic groups. While innovations such as continuous glucose monitors and insulin pumps have revolutionized diabetes management, their benefits are often limited by inequitable access and systemic barriers within insurance policies. To truly address these disparities, healthcare policymakers, insurers, and advocacy organizations must evaluate how current policies amplify inequities and consider reforms that prioritize equitable access alongside technological advancements. By balancing the push for innovation with an emphasis on accessibility and affordability, stakeholders can ensure that progress in diabetes care benefits all patients, not just those with privileged access to resources.

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