Thesis Project Portfolio

Design of a novel *ex vivo* murine brain slice model for analysis of pericyte morphology in diabetes

(Technical Report)

An Autoethnographic Perspective on Type 1 Diabetes Burnout

(STS Research Paper)

An Undergraduate Thesis

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Sociotechnical Synthesis

Type 1 diabetes (T1D) is a persistent and complex medical problem that poses many unique challenges to millions of people in the United States. Of these challenges, two of the most pressing are the somewhat abstract emotional toll that blood glucose management takes on a diabetic and the much more concrete physical repercussions that arise as a result of inconsistent personal care. Awareness of the diabetic experience and the resiliency that diabetes management requires needs to be raised because prevalence of diabetes is increasing (Wild et al., 2004). The STS Research Paper, "An Autoethnographic Perspective on Type 1 Diabetes," and the technical report, "Design of a novel *ex vivo* murine brain slice model for analysis of pericyte morphology in diabetes" provide the general audience necessary information to understand the emotional and physical complications of diabetes, respectively.

T1D is an autoimmune disease in which the pancreas no longer produces enough insulin to regulate blood glucose (BG) levels, resulting in chronic high BG (hyperglycemia) that is treated with exogenous insulin delivery. Patients affected with this condition must do manually what a healthy body does autonomously, and the attention required to maintain healthy BG levels can cause overwhelming feelings of exhaustion and frustration in response to the challenging requirements of BG management, defined by the term "diabetes burnout." Diabetes burnout is associated with suboptimal BG management and severe hyperglycemia, leading to increased risk of blood vessel damage, organ damage, and hospitalization. The prevalence of T1D is increasing in the United States and there is no standardized treatment for patients who suffer from diabetes burnout; therefore, it is important to explore the pathology and experience of burnout patients, and offer potential solutions. Thus, the STS research question, "What are societal, physical, and emotional consequences of diabetes burnout, and what are the potential solutions for those who struggle with this condition?" will be conducted through the framework of wicked problems. This framework will be utilized to emphasize the scope of diabetes burnout and its main contributors. An autoethnographic analysis describing the author's personal experiences with diabetes burnout will be paired with wicked problem framing to offer palliative care to burnout patients. The analysis conducted here proposes novel alternatives to patients who struggle to live with and manage a difficult disease.

In addressing the vast medical problem of microvascular complications of diabetes, a disease complication that affects more than 30 million Americans (CDC, 2020), the Technical Report is a design project that proposes a novel extracellular vesicle (EV) therapy to stabilize brain microvessels in diabetes. During periods of chronic high blood glucose (hyperglycemia) as seen in diabetes, cells of the microvasculature called pericytes (PC) that communicate and signal to the structural cells of blood vessels called endothelial cells (EC) begin to detach from blood vessels and lose functional capabilities. Also referred to as PC dropout, this disease state can result in blood vessel necrosis and the progression of diabetic microvascular complications such as retinopathy, neuropathy, and nephropathy. EVs are lipid-based particles produced by most cells in the body that contain proteins, DNA, and RNA, and show promise as a regenerative medicine candidate (van Niel et al., 2018). After isolation from urine, plasma, or cell cultures, these vesicles contain highly specific contents that can be used as a signaling method upon delivery to EC and PC to reduce detachment and return to expected interactions observed in normoglycemic environments. The research team, composed of Garrett Johannsen, Stephen Muzyka, and Connor McKechnie, hypothesizes that the use of EVs to target tissues in hyperglycemic environments will restore healthy PC/EC interactions. If successful, the downstream implementation of this therapy could serve as a direct treatment for microvascular complications of the brain, and a successful EV protocol could initiate similar therapies for related complications of diabetes. An EV treatment would improve quality of life for diabetic patients and reduce the high medical expenditures each year due to diabetic microvascular complications.

The field of biomedical research proposes novel alternatives and innovative solutions to complex human health problems, and this cannot be done without having an understanding of the biomedical problem at hand and how it affects patients. Through writing the STS Research Paper, and while analyzing my personal experience of living with T1D, it became clear that the problems of diabetes are far beyond the scope of physiological consequences that the disease poses on its patients. The future implementation of the Capstone project would hopefully provide a source of relief to the physiological complications of diabetes, but how would it affect the livelihood of a T1D patient suffering from diabetes burnout? Questions like this one are very important to consider when designing engineering solutions, and the patients should always be at the center of the design process. The STS Research Paper emphasizes the importance of creating medical technology that improves convenience and quality of life for the patient, whether this is in the form of a smaller, cordless insulin pump, or a novel treatment option that every diabetic patient can afford, to name two examples. When a biomedical expert considers the psychosocial, socioeconomic, emotional, mental, and physical state of the patient, the resulting innovation is more likely to accurately address an aspect of a wicked problem, and more compassion is brought into the field of engineering.

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