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Transport infrastructure evaluation using cost-benefit analysis: improvements to valuing the asset through residual value—a case study

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Innovative Concept Model Design for Linking Physicians to the System of Patient-Centered Care with Advancing Technologies in the World of Diabetes

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This concept paper applies the concepts of complex sociotechnical engineering systems to the care and management of type 2 diabetes. It also includes an innovative design model that integrates the existing ecosystem of care and management of diabetes. This model could potentially improve quality of care, create transparency of information between patient and physician and decrease the overall cost of care of diabetes.

With the recent transitional phase of healthcare, when the Accountable Care Act is in play, being able to understand and relate the many different variables in a complex sociotechnical system could mean the difference between a successful or unsuccessful healthcare system management strategy. By looking at the existing chronic patient care model from a systems perspective, we can better understand the importance of each stakeholder at a larger scale. We can also benefit from the advancing technologies including the electronic medical record (EMR) system and patient self-monitoring devices. This proposed integrated model of care can help resolve important issues in the care model, such as, patient-physician communication problem throughout the treatment process of chronic diseases like diabetes.

Patients with diabetes are required to follow up with their physicians every six to twelve months. This creates a communication and patient progress information gap between follow up patient visits. Patients are also required to self-monitor and self manage until their next follow up appointment. Physicians view this time period between appointments as being critical since it is difficult to assess what changes happened during these intervals. Almost all preventable diabetes complications develop during these time intervals. This integrated systems approach would allow the patient monitoring devices to communicate with physicians, and eventually support groups, continuously using the advanced electronic health records through out their process of care and management of diabetes. It would also provide patient information to physicians during these critical time intervals and potentially improve the diabetes prevention care model. This improved care model is designed to alert physicians whenever the patient's data shows a decline in health progress. Physician would in turn assess the patient immediately and may involve patient support group if necessary. The support group consists of a navigator or social worker, family or friends' circle, and a psychologist to assess the condition/state of the patient. Thus, in this holistic design model, the whole diabetes ecosystem of care would be involved with patient centered care and management. This proposed diabetes care model could potentially improve the efficiency of preventing diabetes complications and thus lower the cost of the healthcare system.^{1,2}

We believe this integrated systems approach would be eventually beneficial to the entire diabetes ecosystem.

Describing the Diabetes Care and Management Ecosystem (Figure 1)

Our approach to study the complex diabetes ecosystem is through an engineering systems perspective. Massachusetts Institute of Technology (MIT) defines Engineering Systems as a field of study that deals with studying, re-designing, resolving, managing and improving the problems of complex sociotechnical systems. It uses an integrated systems approach that involves various engineering disciplines as well as other fields like public policy, economics and other sciences.

Using an engineering systems approach, modeling the care delivery healthcare ecosystem for type 2 diabetes patients allows for a greater understanding of the variables of interest. By differentiating and manipulating the various subgroups and stakeholders in the model, we can understand their importance at a larger scale.

In terms of the care management system in healthcare, there are many important hidden key variables involved. (Figure 1)

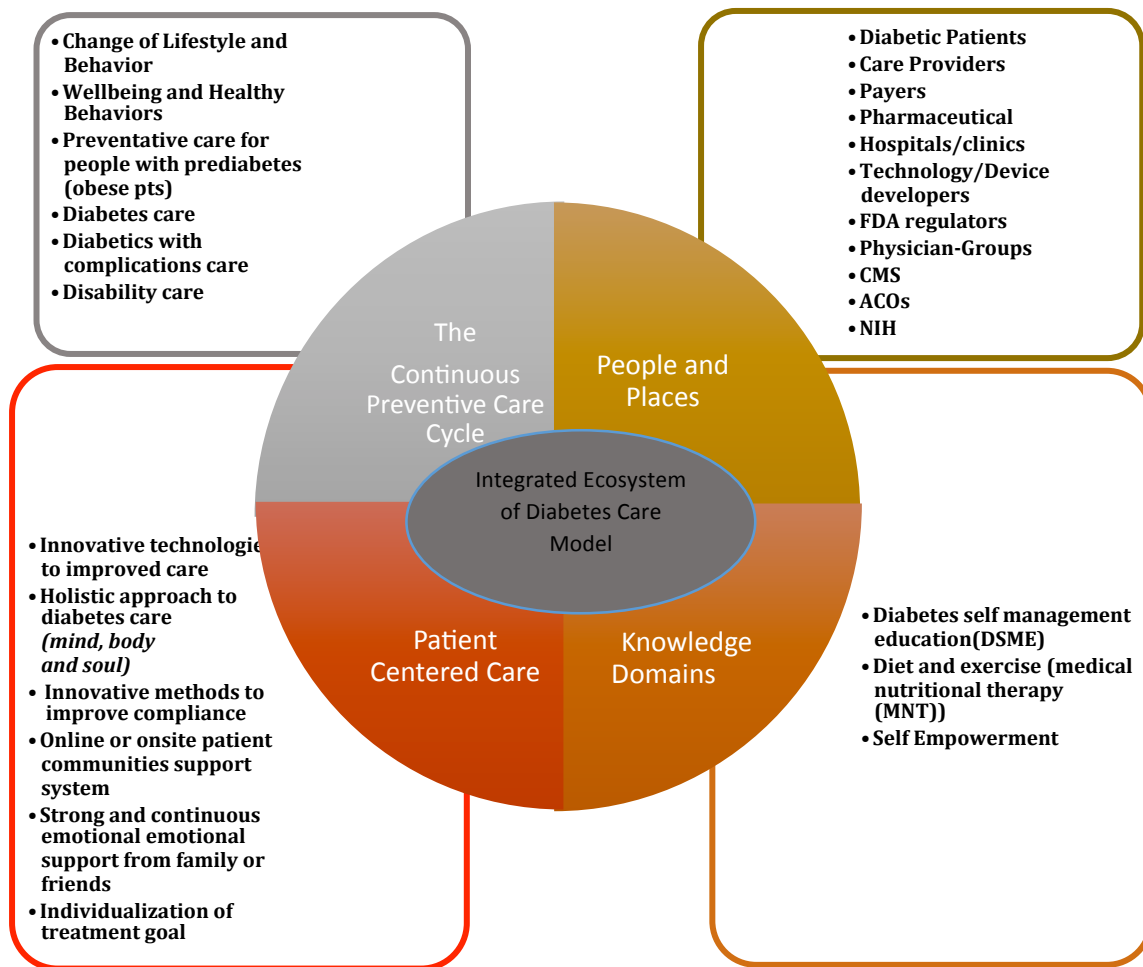


Figure 1: Diabetes Care and Management Ecosystem Model viewed as a Complex Sociotechnical System.

The **continuous preventive care lifecycle** approach within the innovative behavioral care model system includes the stages of preventive care of the patients with diabetes. They can belong to an overweight/obese patient group and get involved in an interactive behavioral modification system to prevent the development of diabetes. Prediabetics who use this integrated modification systems approach can revert back from the prediabetic stage to the non-diabetic stage. Similarly, late-stage diabetics can use this approach to prevent diabetic complications. Furthermore, this model could prevent patients that develop complications (e.g. heart disease, renal failure, etc) from progressing further into disability. The value added in this component of a system can thus be modeled by its potential improved effectiveness and therefore could bring change in the quality of an individual's lifestyle and help lower cost. ^{3,4,5,6,7}

In reference to the **people and places (stakeholders)**, there is a need for incentives for patients and providers as well as payers, hospitals, pharmaceutical companies, technology/device developers (entrepreneurs of healthcare industry), FDA regulators, the physician's groups and research institutes to all move together toward a more accountable and financially viable system. It is important to develop an integrated system that not only takes into account the quality of care, but also the viability of a business model of the healthcare system and thus help align all the important variables of the system of care. ^{8,9}

Knowledge domains encompass a large area of unexplored territory. While many people see education as a limiting factor in the current state of healthcare, it can also be treated as an opportunity for growth. Because there have not been large investments into chronic illness education until recently, it is an area that could have very significant effects. The marginal benefit would be very large with respect to lifestyle modification and changes. Although much has been done policy-wise to introduce healthy foods in the market, education can help to fight bad diets in ways that regulation cannot. Using education and knowledge as a metric is increasingly important because of the value of social capital. With a more educated public, the system of care lifecycle can effectively utilize its resources to manage diabetes. Educational programs like Diabetes Self Management Education (DSME) and proper diet and exercise (medical nutritional therapy (MNT)), approved by the American Association of Diabetes, are good examples of the improved education system for chronic diseases like diabetes. ^{10,11,12,13,14,15,16}

Patient-centered care is an important component in this behavioral model design. Patient-centered care involves a treatment and management approach in which patients' needs, values, and references are taken into consideration during clinical decision-making. Patients' self-management, which includes participating in an educational diet and exercise program and support group system, self-monitoring using the latest monitoring devices, using a holistic approach (e.g. regular yoga, meditation, relaxation therapies etc.) besides the traditional management approach, dealing with compliance issues, and participating in online patient communities, all come under the umbrella of patient needs, values, and preferences. There is a lack of research in each area of this approach. We need to study and understand the problems patients face during self-management and self-monitoring. ^{6,7,15,16,17} Currently, it is unknown if the latest technologies/devices that are available in the market to self-monitor and self-manage are beneficial for the patients and eventually to the complete care system. We then start wondering if these technologies (patient monitoring devices) were integrated into the system that involves physicians' interaction with patients, physicians' interaction with other stakeholders and

support groups as well as the ongoing evolving knowledge of medicine in a more structured and organized manner; would this be a more effective and sustainable system of diabetes care?

Understanding the system holistically allows us to see the interdependences between the different categories. The system behaves like an ecosystem, in which each part is dependent on the other part. The way to understand this system holistically is to examine the relationships both in inter-groups and intra-groups. By studying these relationships, we can better understand the system and allow for growth and effective integration. This growth enhancement can then be obtained through goal-directed management into the holistic system.

For a system to supersede any previous system, it must reach benchmarks within each of the main categories and add value to the system in question. Keeping this system of design in mind, we should first understand the complexities that are associated in this system of care and management.

Complexities of Diabetes Care and Management System

There are several aspects to consider in understanding the sociotechnical complexities of diabetes care and management:^{18, 19, 20, 21,22}

- **Cognitive** aspects- Many find losing and controlling weight difficult and many diabetics will lose motivation to continue managing their diet and physical activity, which is important to consider when devising a system because it means patients will often need coaching, encouragement, support groups and may even require creative interventions e.g. Online patient educational communities etc.
- **Social** aspects- These relate to the patient-provider relationship. In order to combat a chronic illness like diabetes, a strong relationship between the patient and provider is important for success and it is impossible if the provider cannot give the patient the necessary attention through out the many years of the treatment process. With advancing technologies we can potentially work towards developing an online communication model system that would resolve this problem of communication between physicians and patients. There is also a need for a strong support system, whether it is from family or friends, in order to maintain the motivation and compliance of the patient.
- **Technical** aspects- It is crucial to devise a quantitative system, which allows physicians to track and monitor their patients, as well as the other patients in the region who are receiving comparable treatment. This is the kind of technical aspect Joslin Diabetes Center has begun to address and will aid in the efficiency of diabetes treatment.³ In this paper, we propose a technical, innovative and behavioral model of the system of care for patients with diabetes, which might prove beneficial if designed and implemented properly.

Engineering Systems' Principles and Concepts

Micro/Macro Question: With diabetes, there are numerous environmental, individual, genetic, and economical constraints in managing the disease. Because of the incredible number of specific parts in the diabetic ecosystem, all factors must be considered in order to develop a successful larger system. Ignoring individual and environmental factors often results in no improvement in the patient.⁴ Thus, in a diabetic ecosystem, it is really the effective individual diabetes' care and management which is a micro question, because all components need to be considered and combated, especially the lifestyles of patients with diabetes. From a macro scale, our goal is to minimize burdens on our healthcare system

since current diabetes care and management is very costly and inefficient.

Life-Cycle Properties: One of the emerging realizations across the globe is that if the current obesity and diabetes trends continue, there will be a steady increase in the cases of diabetes in the next decades.¹ Thus whatever diabetic care delivery system is implemented now, it may be helpful when, in forty years, one in every three Americans is diabetic.² Two lifecycle properties, in particular, are deemed critical:

- Flexibility in the system- to make a successful diabetic care system that will be flexible with the increased demands that will arise. If the trends continue, the system will need to focus more on proactive treatment of pre-diabetics or diabetes prevention, especially in the obese populations, instead of diabetes care and management.^{1,2} If the system is flexible then it will accommodate for the uncertainty in demands.
- Sustainability- to make an economically efficient system that will be practical and sustainable over time and will address the problem of physician time limitation. With increased cases of diabetes there is no way a physician can give the individual attention needed. Development of a system using another provider or with an online technical system that determines the attention each individual patient needs is necessary.

Focusing on Feasibility: Ideally, there would be a system in which patients could get the full attention they need and the environment would cease to be filled with unhealthy food. However, that is not feasible. With an increase of diabetes and obesity across the globe, a satisfying solution made in a timely manner is the most important issue for diabetes care as diabetics progressively develop fatal complications if not controlled effectively. For example, the recent step taken by FDA to regulate the use of trans fat in diet may be the timely feasible solution of the growing problem of obesity.

Dealing with Uncertainties: ^{23,24} With diabetes, there are several uncertainties as we observe with any existing care system. The responsibility and behavior of the patient in self-management and self-monitoring process is always uncertain and that is what new innovative interventions and the education system attempt to combat.

System Safety Concerns: There are several safety concerns in diabetes management. Some of the weight-loss techniques are unhealthy and inefficient as they lead to abnormal metabolic changes, which is harmful for the patient. One diet program cuts around 500 calories a day, which is often suggested in the management process. However, if not applied properly can lead the body's metabolism to shock. Lack of sufficient information and human errors can contribute to serious system safety concerns such as wrong choice of weight management programs, issues with lack of sufficient knowledge about the disease, self management and compliance issues etc.

Proposed innovative and integrated design of diabetes patient care model using advanced technologies. (Figures 2&3)

This proposed concept model provides continuous monitoring and treatment for diabetes, a system of care not currently available. Using this model, patients are involved in ongoing educational self-managing interactive programs, and the data is collected automatically from patient monitoring devices to cell phones. This information, which is transparent to patients, is sent to the device data collection center (icloud) and then transferred to the (Up to Date) research data center where scientists continuously analyze this information to improve patient health and treatment outcomes and eventually the treatment protocols. Endocrinologists (diabetes experts) or Primary care physicians have access to this database, as do any other physician who needs to evaluate patients at some point, e.g. emergency physician. They continuously check on patients remotely and through the Electronic Health Records (EHR) systems of the hospital. Whenever patient's data shows a decline in progress, the physician of the patient is alerted immediately. Physicians then involve the support group as explained earlier. *(Figure 2)*

We believe that existing advanced technologies that this proposed system successfully leverages technology to ensure improved patient outcomes for chronic disease patients. This technology integration can therefore provide a more efficient and improved system of care and management. *(Figure 3)*

The concept is similar to the current banking and utility systems in which the customer can monitor his/her own online accounts and receives an alert whenever a problem or suspicious activity is noted. For example, NSTAR's electricity-billing system sends an alert whenever the bill is higher than usual and also shows why it might be higher by sharing the details with the customer. NSTAR even provides customers some educational links on how to save energy and suggest mediation approaches such as turning off computers, using energy efficient light bulbs etc.

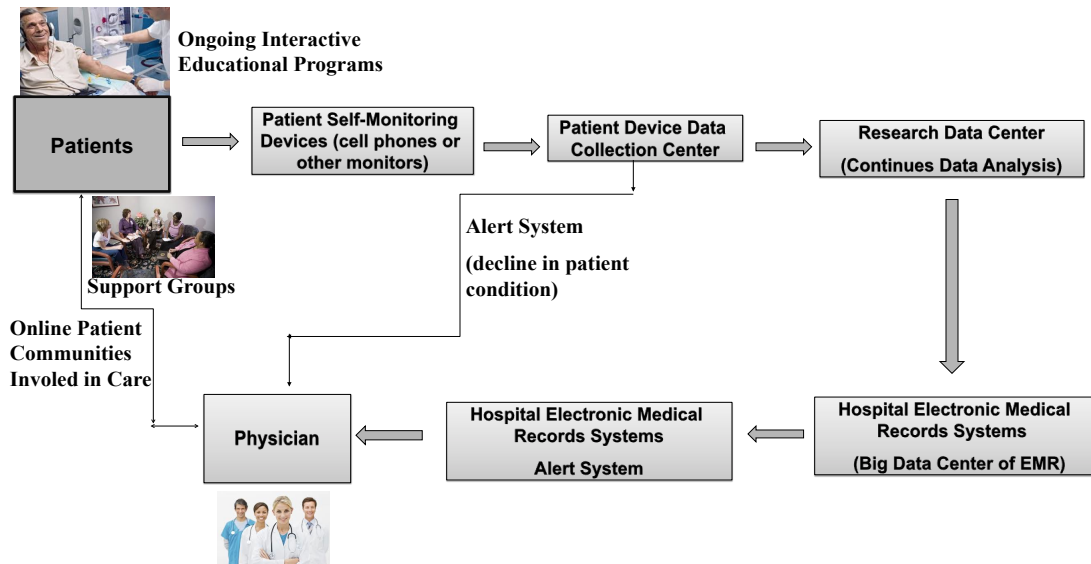


Figure 2. Proposed innovative concept model of diabetes care and management showing patient information flow in the system.

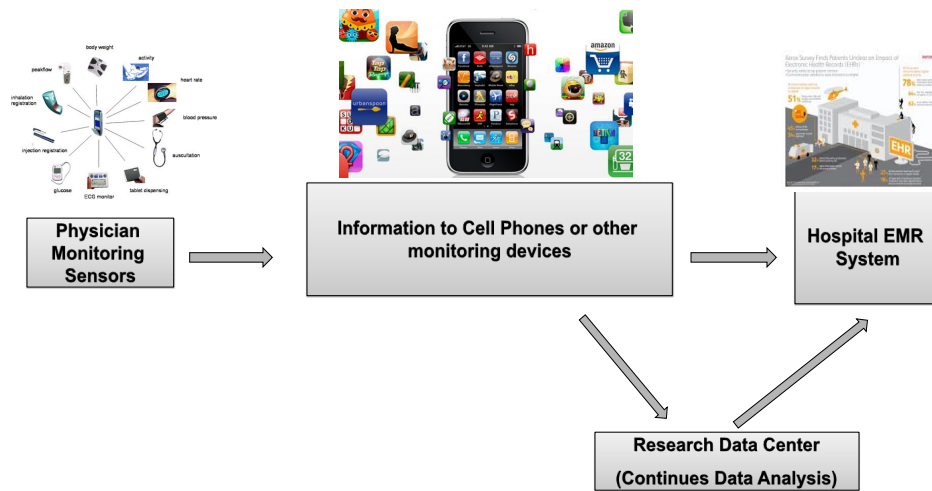


Figure 3. Technologies Integration proposed in this concept diabetes model.

Conclusion:

This proposed system of care model is a classic example of a complex sociotechnical system in which we observe a variety of complexities. We have viewed the diabetes ecosystem from an engineering systems’ perspective. We have created and proposed an innovative, integrated, patient-centered care model, which could resolve the problem of physician and patient communication in the lengthy process of diabetes care and management. This proposed model will need an immense amount of research to properly develop, implement, and then run pretests and post-test experiments in order to evaluate the efficiency and cost effectiveness.

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