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Existing Approaches to Engineering Design in Health Care are Classified

Hadi Nabahat*

Iran University, Russia

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***Corresponding author:** Hadi Nabahat, Iran University, Russia

Abstract

Prognostics and health management (PHM) is a technology that enables the reliable, efficient, cost-effective, and safe functioning of engineering equipment, systems, and structures. This paper proposes a categorization of existing approaches to healthcare-related engineering design based on systems thinking principles. Three existing approaches to healthcare-related engineering design are isolated which contribute differently to health systems fundamental purposes and interconnections. The three approaches are labeled as 'silent', 'overt', and 'convergent' health design. Each approach is defined and illustrated through an example. Following, practical advantages and disadvantages of each approach are discussed. A reflection is offered on the expected relevance of the convergent health design approach for present and future societal challenges in the health domain, and specifically on the recently growing field of e-health. Finally, open methodological challenges related to convergent health design are outlined and characterized as opportunities for future research.

Keywords: Participatory Design; Biomedical Design; Systems Thinking; Systems Engineering; Prognostics and Health Management

Introduction

Engineering design disciplines have been mentioned as a subject of study that is pertinent to the support of health systems in general numerous times [1]. Particularly, fields like information technology, human factors, and ergonomics have been explicitly promoted as desired allies of extensive health-related endeavors [1,2]. Some authors have emphasized the need for design engineers to "better understand the healthcare systems, including the users of that system, as the context into which specific design solutions must be delivered" in order to maximize the effectiveness of the partnership between engineering design and healthcare. Since then, various health-specific engineering design methodologies have been codified, including the Biodesign process[3], which incorporates a component of "direct immersion" in clinical situations to uncover unmet needs. However, rather than achieving systemic influence through particular engineering design processes, these approaches are mainly intended to assist practitioners in formulating propositions that "fit" in existing health systems [4].

A systems-based approach to healthcare product and service design was requested after it was recognized that current engineering design approaches are limited in their ability to produce value for the entire health system. The current contribution should be viewed as a reaction to this demand's theoretical component.

The study provides a classification of current methods to health-related engineering design that is based on the ideas of Arnold and Wade's systems thinking (2015) [5]. What are the distinctions in how various design-engineering methodologies lead to systemic influence in the health domain? is the general research topic.

The systemic prognosis for health systems: a two-way street

Systems are characterized as consisting of elements, relationships, and a function or purpose in conventional systems thinking literature. The structure we present for health systems in general, derived from standard definitions, can then be expanded upon to define particular health systems with their unique features [6]. The supply of health services to the population is the culmination of a health system, which is traditionally characterized as "the mix of resources, organization, financing, and management." In order to give health services to the population, health systems must include at least two components: [1] the health providers; and [2] the health recipients, who can be variably referred to as the "people," "patients," "customers," or "citizens" depending on the frame of reference [7].

Additionally, the two key components of health systems have at least one connection to one another and are interdependent on one another. For instance, some frameworks designate the recipients of healthcare systems as the "demand-side," differentiating them from the mechanisms for creating and distributing healthcare, which are designated as the "supply-side." [8,9] In this way, ties between health recipients and providers can be seen of as both "push" connections and "pull" connections. The information flows moving through the system, which go both from health providers towards health recipients (such as when doctors advise patients about ailments) and from health recipients towards health providers, [9] also show the two-way nature of the interconnectedness (e.g.in the case of patients describing symptoms to their doctor).

The domain of health practice or health services, which is defined as "all services that have as their primary objective the improvement of health," can be understood as the inputs coming from health providers and going to health recipients. The relationship between health research and practice has long been the subject of scholarly discussion [10]. The 'knowing-doing gap,' which is defined in clinical literature as the 'gap that occurs between what we know works based on the best available data and what we clinically practice,' has been problematized as systemic dysfunctions in the links between the two domains. The knowing-doing gap is a significant problem in contemporary medicine because it negates the advantages that can be obtained from breakthroughs in medical knowledge.

Result and Discussion

Approaches comparison

There are a number of restrictions on the current research. First of all, the three ways were identified by a purely conceptual process, and completely different techniques might have been discovered through practical research methods [11]. Second, identifying and analyzing the methodologies is limited to prior initiatives and does not always offer guidance on how to structure new ventures to achieve the required level of systemic impact. Further investigation would be necessary, including rigorous evaluation of a greater volume of health design projects of each kind, in order to make any considerations of this nature. In terms of the practical benefits and drawbacks we may anticipate being connected with each technique in terms of the complexity of the process and the features of the outcomes, a few preliminary considerations can be made [12]. Comparing quiet health design to the other two techniques, it has the practical advantage of being clearer and simpler [13], which leads to a quicker and less expensive process for creating health artifacts.

However, the strategy has the drawback of only relying on the initiative and originality of a person with prior clinical experience. While such occurrences should undoubtedly be embraced, they shouldn't be seen as formal obligations for healthcare professionals, who are typically trained to adhere to procedures rather than think outside the box. Limiting the creation of health products and services to such coincidental occurrences would mean missing out on innovative chances that may be acquired by having people who have been "trained" in product or service development use their talents in the clinical arena [14].

Overt health design has a practical benefit over the other two techniques in that it explicitly incorporates a knowledge of users and their context into the design process while still providing a relative amount of process agility in comparison to convergent health design. The lack of a solid clinical evidence base, however, could potentially have negative effects on outcomes quality in terms of 1) clinical performance, and 2) the readiness of health practitioners in general to embrace the generated health artefact in clinical practice.

Convergent health design has the ability to establish a "closed loop" of information transmission between health practitioners and recipients, allowing for beneficial influences in both directions, which is a practical advantage when compared to the other two approaches [15]. However, this approach is expected to have some drawbacks, including a particularly high degree of complexity, which results from 1) the requirement for close multidisciplinary alignment between design engineers, health researchers, health recipients, and possibly other stakeholders, and 2) the necessity for time-consuming and expensive clinical research procedures. In conclusion, it is argued that each of the stated techniques should be viewed as having a different impact on health systems, even while none of them should be seen as necessarily being desirable.

Different engineering design approaches are anticipated to prove more advantageous than others depending on the difficulty and the specifics of the targeted health system at a given time. As a result, the differentiation between the three methods represents a development in the theoretical understanding of design engineering's systematic contribution to the health domain. Last but not least, it is significant to note that the three techniques can coexist peacefully, even inside the same business or research institution.

Conclusion

In this study, three alternative engineering design approaches to the creation of health artifacts were described. The methods were labeled as "convergent," "overt," and "silent" health design. The definitions and examples for each strategy were provided, along with a discussion of its advantages and downsides in real-world situations. The relevance of convergent health design for impending social concerns in the health domain was discussed. Finally, methodological issues with convergent health design were described and framed as potential areas for further study.

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