Healthcare systems are becoming increasingly conscious of the quality of care delivered, along with the provision of value-driven services. Nevertheless, the majority of innovation in the realm of healthcare has been focused on products and services. Beyond being the major contributor to healthcare expenditure, these technology-driven innovations treat medical staff as the primary stakeholder and do little in the way of improving the quality of care for patients. This presents an opportunity to explore other forms of innovation in the context of healthcare. As a human-centred approach, design offers a method for holistically exploring problems, meeting stakeholder needs, and has been established as a means of driving innovation. This paper suggests that a design-led approach to innovation could increase quality of care and assist in creating value-driven services. To conclude, the paper contributes a framework, along with a set of examples, detailing four design objectives in the context of health and medicine.

Innovation; design-driven; medical design; health and medicine

1. Introduction

Recent years have seen an increase in focus on value and quality of care in global healthcare systems (Kaplan, Porter, & Herzlinger, 2011; Olson, Dias, & Stowell, 2017). Despite numerous positive developments following this initiative, healthcare systems are complex, and often difficult to change. A major contributing factor is the need for healthcare systems to address the needs of numerous stakeholders (e.g., patient preferences and values, cost, efficiency, etc.) (Hunink et al., 2001; Porter & Lee, 2013). Even small changes in these systems, which could be easily implemented in other disciplines, are comparatively difficult to diffuse in healthcare. These difficulties manifest due to a range of issues; healthcare innovations require the navigation of multiple stage-gates for approval, face regulatory issues, require the support of leadership and management, and rely on the expertise and collaboration of numerous disciplines (Hanna, Manning, Bouxsein, & Pope, 2001).

Innovation in the context of healthcare has continued to focus on the design of medical products and devices (Norman & Verganti, 2014; Ogrodnik, 2012), which, as technology-driven solutions, have
been cited as the primary driver for rising healthcare costs (Burns, 2012). While there is pressure to maintain and improve clinical standards in line with new technological developments, such innovations do not always support recent initiatives which aim to bring greater focus to the value and cost of innovation in healthcare. Furthermore, several studies show that non-technological solutions to health care challenges can have significant outcomes for both patients and medical staff (Brown, 2008; Norman & Verganti, 2014). Indeed, these design-led solutions require considerably smaller investments of time and resources, and offer an established method for understanding and addressing the needs of multiple stakeholders (Fraser, 2007).

While technology-driven solutions have their place in the context of healthcare, this paper proposes that design offers a method for better understanding healthcare challenges and conceptualising solutions which address growing demands for value and quality of care. This paper therefore explores the role of design in healthcare, presents a method for interpreting design opportunities in healthcare, and contributes a brief overview of prominent challenges and opportunities present in healthcare.

2. The role of design

The landscape of design is shifting (Buchanan, 2016; Heskett, 2001). Design, despite origins of making and styling, is progressively being adopted as a method of problem solving (Muratovski, 2015). Indeed, design is increasingly being recognised as a means of holistically unpacking complex problems and conceptualising solutions to address the needs of all stakeholders (Carlopio, 2009); even in areas not traditionally seen as the domain of design (Brown & Wyatt, 2010; Dorst, 2015).

In his earlier works Heskett defined the word ‘design’ as a noun (i.e., the general field of design, a plan or intention, or as a finished product) and as a verb (Heskett, 2001). As the discipline of design has evolved the role of design as a verb, i.e., as a thought-process, has become increasingly prominent (Brown, 2008; Manzini, 2014). While a plethora of methodologies embody this notion (Brown & Martin, 2015; Verganti, 2009; Wrigley, 2016), proponents of these methodologies agree that innovation, human centred design and understanding through observations are core elements of design (Brown, 2008). The design process typically begins with a holistic understanding of a problem, unpacking the customer’s needs, the end-user’s environment, social factors, market adjacencies, and emerging trends. Design looks beyond the immediate concerns of a problem, ensuring that the right dimensions are addressed (Carlopio, 2009; Holloway, 2009).

Design is often comprised of both theoretical and practical elements. Toggling between theoretical (abstract) and practical (concrete) realms allows design proponents to adapt observations and experiences from the concrete world into frameworks (insights) through a reflective process (Beckman & Barry, 2009; Buchanan, 2001). These insights are an articulation of the stakeholders’ latent needs, and are fundamental in realising innovative design outcomes.

3. Design in healthcare

This study is set against a growing body of work which calls for a rethink of the traditional approach to designing for social outcomes. Notably, Design for Public Good (UK Design Council, Danish Design Centre, Wales Design, & Aalto University, 2013) presents the value of responding to social challenges through a design-led approach. The need for innovation in the social sector is, for the most part, extensively outlined in prevailing literature (Liedtka, Azer, & Salzman, 2017; Shin & Mcclomb, 2013).

Traditionally, design in healthcare has come in many shapes and forms, with design methodologies being used to explore a range of products (e.g., Bode, 2009; Malkin, 2007; Ogrodnik, 2012), services (e.g., Carr, Sangiorgi), Büscher, Junginger, & Cooper, 2011), processes (e.g., Plsek, 1997), and systems (e.g., Porter & Lee, 2013). While design has been established in healthcare, the applications of design in this area are mostly traditional (e.g. architecture and industrial design), with a plethora of unrealised opportunities. In their publication Nusem et al. (2017) outline four types of design utilisation, these include:
1. Solution-Centred Design - design primarily viewed as a means to solve an emerging and well-defined problem in practice;
2. Social-Centred Design - design used to achieve social outcomes, with design usually limited to a product or service and the desired outcome of the engagement often being predetermined;
3. Design for Competitiveness - design focused on driving innovation at the level of strategy or business model. Design is used holistically to define opportunities in practice, yet characteristically there are external forces or an internal vision driving change; and
4. Design for the Greater Good - design is used to drive strategy at a business model or policy-making level for the purpose of realising social outcomes.

Of the healthcare design examples previously noted, most fall into the first two orders of solution and social-centred design. In public healthcare, this could be attributed to change which is mandated, driven externally, or poorly funded and staffed. Indeed, even innovations which are well funded and supported can often fail. Admittedly, the journey to successful change in healthcare is rife with a multitude of barriers, including: (i) inefficient handovers between analysis, solution and implementation; (ii) a disjointed mix of various incremental solutions to challenges as they arise; and (iii) ill-considered and rushed pilot studies which are often expensive or risky (UK Design Council et al., 2013). Design addresses these issues by offering (i) a collaborative approach, which (ii) looks at systems and problems holistically, begins by understanding each of the stakeholders needs in order to ensure that any solution generated is appropriate, and (iii) iteratively tests through low-fidelity prototypes which design out risk (Nusem, Wrigley, & Matthews, 2016). As such, design is an appropriate methodology for overcoming the aforementioned challenges.

As a method of meeting stakeholder needs and solving problems, design has been established as a means of driving innovation (Plattner, Meinel, & Leifer, 2014; Wrigley, 2016). Organisations depend on successful innovation to thrive and meet the needs of their stakeholders, but even in fields such as healthcare, innovation is often seen as a luxury or burden when it should be seen as a core activity (Burns, 2012; Mulgan & Albury, 2003).

4. Interpreting design opportunities

Design problems are often highly complex (Dorst & Cross, 2001). Indeed, even once a need or opportunity has been identified in practice, there is a need to understand the type of design required to address it. This concept has been explored in literature, with several authors outlining and mapping a design proponent’s capabilities to their capacity to address a problem (Dorst, 2015; Dreyfus, 2004; Lawson & Dorst, 2009). Mosely, Wright and Wrigley’s (2018) framework, presents a synthesis of a series of models that investigate design expertise, and describes seven types of design across four levels of complexity. The framework outlined by Mosely et al. describes the types of design associated with, and required for addressing, a given problem in practice (see Table 1).

| Design Type          | Complexity | Description                                                                 |
|----------------------|------------|-----------------------------------------------------------------------------|
| Result-Focused       | Simple     | Design follows ‘the rules of the game’, concentrating on design conventions, customs and habits, and the set ways of working within a field (e.g. concentrating on the user and designing from their perspective) |
| Convention-Based     |            |                                                                              |
| Situation-Based      | Complicated| Design is used to understand the situation or context and to create a response specific to that particular setting (e.g. identifying the ‘core problem’ of the problem situation) |
| Strategy-Based       |            |                                                                              |
| Experience-Based     | Complex    | Design is concerned with the process and development of new                   |
### Design Type Complexity Description

| Design Type                  | Complexity | Description                                                                 |
|------------------------------|------------|------------------------------------------------------------------------------|
| Developing New Schema        |            | ways of working which are imposed upon a problem (e.g., reframing the design problem to develop something new) |
| Redefining the Field         | Chaotic    | Design is revolutionary and disruptive, where the designer explicitly aims to redefine the field (e.g., the entire problem and solution are reconceptualised) |

Beyond a classification of the types of design and their complexity, this paper seeks to categorise healthcare challenges and opportunities and to identify the corresponding level of design required to holistically address them. The author therefore offers a synthesis of two frameworks with the aim of exploring healthcare challenges from a design perspective. The framework identifies four basic objectives for using design in healthcare. These objectives differ fundamentally across two dimensions. First, by the degree to which the design context is constrained, i.e., whether the design must explore something specific (e.g., a single element of a challenge or opportunity) or where the scope is open ended. Second, where design is utilised to realise a prescribed (from a set of established options or in mimicry of prevalent trends) or an unprescribed outcome. The four quadrants identified in the framework also correspond to the degree of complexity which must be addressed by the designer, with problems becoming increasingly complex as the framework moves from the first to the fourth quadrant. The framework depicts four objectives for design utilisation in healthcare, as shown in the quadrants of Figure 1, with the matrix segmenting the objectives across the two aforementioned dimensions.

#### 4.1. Result-centred design

In the first quadrant design is predominantly used to address a preselected context, where the criteria of design are not challenged and there is a prescribed type of outcome (e.g., to reduce the size of a product). As it is not within the scope of design to holistically unpack the context there is often a tendency to jump straight from the identification of a problem to the design of a solution. Only a basic understanding of design is required, and the design proponent can be novice or naïve yet still address all requisite criteria. Problems which are oriented towards issues experienced by staff (e.g., efficiency, workload, technical challenges, etc.) are often descriptive of this quadrant, as these are easy to identify and articulate. Such challenges don’t require a deep sense of empathy to identify as most individuals have an intimate understanding of their own immediate frustrations and needs. One example which illustrates this quadrant is an ultrasound scanner designed and developed by Philips.

> “The design contribution for this project involved access to user’s community knowledge by observing and analysing actual conditions of use of the existing equipment in a number of hospitals, which identified mobility as a crucial dimension” (Bertola & Teixeira, 2003, p. 188).

Previous iterations of the ultrasound scanner were large and immobile, which resulted in numerous challenges for medical staff. The design outcome from this project was a mobile console which could be manoeuvred around the patient (Bertola & Teixeira, 2003). This design presents a response to a challenge articulated by staff surrounding the mobility of the previous iteration of the device, with new technologies from existing products being adapted to improve the usability of the new device – a problem was identified and a solution was designed and developed.
4.2. Situation-centred design

While the use of design in the second quadrant allows the designer to holistically explore the problem, the design outcome is prescribed. The design criteria for such outcomes can be more difficult to articulate, and hence require the designer to have a large degree of competency.

Brown (2008, pp. 86-87) outlines one such example of design utilisation, where a group of designers explored the handover of care between nurses. Lacking a standardised method for exchanging information, nurses often worked overtime and failed to exchange critical pieces of information in-between shifts, resulting in patients feeling as though their care was not part of a continuum.

“The design that emerged for shift changes had nurses passing on information in front of the patient rather than at the nurses’ station ... The result was both higher-quality knowledge transfer and reduced prep time, permitting much earlier and better-informed contact with patients” (Brown, 2008, pp. 86–87).

This relatively simple change halved the time between the arrival of nurses and their first interaction with patients. The outcome outlined in this case was prescribed to improving the process utilised by nurses during handover, yet the context in which this happened and the stakeholders involved were not constrained.
4.3. Subject-led design

In the third quadrant design is used to explore a preselected context, yet the outcome is not prescribed. The designer is required to have a degree of expertise in order to navigate the needs of various stakeholders, and may be required to reframe the challenge at hand. This quadrant is often descriptive of challenges faced by patients (e.g., patient experience, value for patient, transparency of care, etc.) due to designs which have previously treated medical staff as the primary stakeholder(s).

One such example can be found in the context of a CT scanner (medical imaging system). Scanners required a relatively lengthy exposure, during which patients had to remain still. As radiographers were perceived as the core stakeholder for these devices, the response was to increase the imaging source’s power and the detector’s sensitivity in an effort reduce exposure time, despite this resulting in a higher dose of radiation. Instead, designers shifted the focus from technological innovation to the patient’s emotional state during the scanning procedure (Norman & Verganti, 2014).

“Philips decided to change the meaning of the experience from that of a threatening, noisy, and uncomfortable medical procedure to a pleasant, relaxing experience. Instead of modifying the technical equipment, Philips modified the hospital environment before, during, and after the scanning procedure. Its redefinition allowed them to focus on the patient’s emotional state, rather than on the technology” (Norman & Verganti, 2014, pp. 94–95).

The redesign of the experience was still limited to the context of the scanner, yet the design outcome was not prescribed. Philips were subsequently able to capture value for a stakeholder which had previously not been considered. Indeed, as the patient experience was not ideal, the focus of this design was improving outcomes for all relevant stakeholders, not just for practitioners or those who commissioned the design.

4.4. Design for innovation

In the fourth quadrant design is used to explore a specific context with the aim of creating novel value for all stakeholders. Challenges in this context are often ill-defined and complex, or lacking an obvious resolution. The design process is required to be holistic in order to meaningfully address and meet all stakeholder needs. Proponents are required to be masterful of design, and must face ambiguity in contexts where no parallel solutions exist. Outcomes are expected to push the boundaries of the field and may redefine the field itself. One example of design in the fourth quadrant is the initiative outlined by West, Davey & Norris’s (2014) to design out medical error.

“Medical error is a widespread problem internationally. Whilst education and training have a large part to play, it is recognised that the design of equipment, graphics, communication, processes, systems and environment can also contribute to error in healthcare. A lack of understanding of the end-user and/or the scenario of use of a design can lead to a confusing and complicated user experience, and can contribute to error. Furthermore, many designs are concerned only with their specific function, and make no allowance for the complex system into which they are placed” (West et al., 2014, p. 241).

While effectively a number of cases which address smaller challenges, the initiative outlined by West et al. presents a holistic attempt to redesign an entire context with the aim of improving outcomes for both patients and practitioners, and is not focused on the individual challenges which are addressed through the initiative.

Collectively, these four quadrants outline the role of design in the context of healthcare. The framework outlined in Figure 1 demonstrates the role of design as a method for responding to challenges and opportunities in healthcare, and provides an overview of the subsequent complexity addressed by design proponents in these contexts. Additionally, the framework describes two major
dimensions of design. First, the framework outlines design which is predominantly focused on outcome, where the type of solution is prescribed. Second, the framework outlines design in which the context is constrained. Designers should be conscious of both of these dimensions, as a prescribed outcome or constrained context inhibits a holistic design process and limits innovation.

5. Discussion
This research resulted in the identification of a number of challenges and opportunities in the context of healthcare, with examples of a number of these issues and opportunities outlined in Table 2. These issues and challenges have been categorised according to which of the four quadrants in Figure 1 are most suitable for addressing them. The following section of the paper elaborates further on the four objectives identified in Figure 1, and is supported by a set of example design scenarios.

Table 2 Design scenarios in healthcare

| Result-centred design                                      | Situation-centred design                                      | Subject-led design                                      | Design for innovation                                      |
|-----------------------------------------------------------|--------------------------------------------------------------|--------------------------------------------------------|-----------------------------------------------------------|
| No consideration of workflow and processes in newly designed environments. | Patients with undiagnosed conditions which are discovered through unrelated treatment. | Staffing issues (e.g., understaffed due to low retention), meaning patients often need a return visit following diagnosis. | Lack of channels for patients both pre and post-care (e.g., initiating care and discharge) to be engaged in their care. |
| Lack of standardised procedure for training and use of equipment. | Outdated workflows that have evolved over time, with no deliberate design. | Patients with visible medical products are self-conscious. | Desensitised staff which see patients cases rather than individuals. |
| Lack of standardised platform in hospital for collecting and storing patient data. | Suboptimal experience in waiting rooms with issues around long wait times for patients. | Prolonged stay in sterile environments, with minimal interaction with other humans. | Services are not value-driven and do little in the way of ensuring optimal patient outcomes. |

Result-centered design is constrained in most senses. In this context there is often a predetermined notion of what needs to be designed or addressed, such as a specific product (e.g., a stethoscope) or an element of a specific artefact (e.g. clunky interface). Table 2 depicts two scenarios where there is no standardised procedure or platform within a specific context. From a design perspective the objective for these two scenarios is clear – to develop a standardised platform or procedure for the specific context. The process is not holistic in most senses, as the designer is often engaged on the premise of completing a task; there is little opportunity or need for the designer to unpack the context and gather insights to inform the design. Given that the process and outcome are so heavily directed the designer only needs a modicum of expertise.

Situation-centred design portrays scenarios where the context is unconstrained yet the outcome is prescribed. Regardless of an unconstrained context, it can be difficult to utilise findings and insights from the design process in the final design outcome, as they may not all be applicable. One such scenario is listed in Table 2, where patients live with undiagnosed conditions which are discovered as they are treated for a separate condition. The outcome here might be prescribed to a method or process for diagnosing these conditions earlier, whereas the context is open as there are many conditions which may go undiagnosed within the various disciplines in health and medicine. Key activities for this design objective may include empathising with stakeholders and defining a problem.
Under subject-led design the context is constrained but any outcome is welcome. The first example in Table 2 depicts one such scenario, where a patient with an external medical product (e.g., a prosthetic) is self-conscious. The context is constrained to a specific issue, yet the outcome can be any manner of design (e.g., a marketing initiative or a product with improved aesthetics). As the outcome is not prescribed the designer is required to gauge the appropriateness of a number of concepts. Key activities include prototyping and testing, necessitating a competent design proponent.

Design for innovation entails an unconstrained context and no prescribed outcome. This is often a complex undertaking, as it can be difficult to best determine the direction for design and the potential outcomes. One such scenario is outlined in Table 2, where services are not value-driven, meaning that patients and medical practitioners don’t do their utmost to ensure optimal patient outcomes. A design proponent navigating such a challenge must be masterful as the scope is broad and warrants the use of all aspects of design.

Beyond increased complexity as a designer moves through the four orders, this framework can assist design proponents to be conscious of the scope of their design project. The purpose of the framework contributed in this paper is therefore not to categorise challenges and opportunities within the framework, but to develop a tool to assist designers to better understand the complexity of a design project. The framework depicted in Figure 1 aims to assist proponents to challenge the scope of their work and to provide a means of progressing it through the four design objectives, allowing for a more holistic design process which doesn’t limit potential outcomes. Of course, many scenarios exist where the context is sufficiently developed and a specific design outcome is warranted. The risk is that while some challenges and opportunities may lend themselves to one of the four design objectives in health and medicine, for many it is not a clear fit. Indeed, by reframing a design scenario a proponent may find that it fits into several of the quadrants in Figure 1.

As established in literature, design methodologies are particularly suited where problems are complex, and solutions are required to address the needs of several stakeholders (Brown & Martin, 2015; Carlopio, 2009). With a number of the problems identified in Table 2 meeting these criteria, this paper proposes that design offers an established methodology for conceptualising, prototyping and testing potential solutions for prominent challenges in the context of health and medicine.

6. Conclusion

This paper has explored the emerging role of design in society, and more specifically in the context of healthcare. A synthesis of two design frameworks was illustrated, with the aim of developing an understanding of the types of design objectives in the context of healthcare, along with the degree of complexity associated with the challenges and opportunities which correspond to each quadrant in the framework. Finally, the paper elaborated on the framework and outlined a number of design scenarios, highlighting the design challenges associated with a prescribed outcome or constrained context.

As this research is only in its preliminary stages, the role of design has been limited to the identification and definition of potential objectives. Future research could provide additional case studies to further validate the four quadrants, explore the applicability of specific design methodologies in the context of health and medicine, and evidence design outcomes in public, private, national and international healthcare contexts.

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