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Holistic outcome-based approach towards sustainable design healthcare: aligning the system purpose through system visualisation

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Holistic outcome-based visualisations for defining the purpose of healthcare system.

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Abstract: Various stakeholders in the complex healthcare systems often prioritise and pursue different purposes, values and outcomes. Understanding/sharing/negotiating the trade-offs between them is a critical action in the development and design of complex healthcare systems. Some approaches like work domain analysis or soft systems methodology attempted to map the complex interactions, but it remains unclear how those maps and visualisations are in line with how people conceptualise in practice. This study aims to explore how designers visualise complex system interactions using healthcare outcomes to define the purpose. A workshop was conducted with 23 designers to generate outcome-based visualisations. The results indicate that designers conceptualise the purpose of the healthcare systems in different ways. Complexity was expressed through organic circles and messy arrows. However, support elements are needed to conduct open visualisations. These results may play a role in developing a visualisation-based method to address the complexity of purpose definition in healthcare.

Keywords: Systems Thinking, System Visualisation, Healthcare Outcomes, Boundary Object, Design Method.

1. Introduction

Systems thinking is fast becoming an essential paradigm to deal with the increasing complexity of healthcare design and development (Carayon et al., 2014; Carey et al., 2015; P. Jones, 2013; Peters, 2014; Waterson & Catchpole, 2016; Wilkinson, Goff, Rusoja, Hanson, & Swanson, 2018). Systems thinking is the ability to understand world phenomena as an interrelated whole complex and adaptive system (Adam & de Savigny, 2012; Flood, 2010; Peters, 2014). Systems thinking aims to assist in the holistic understanding of the system across the different stakeholders involved. But the different stakeholders constantly face disagreements and clash of values even in critical decisions such as defining the purpose of the system.

The purpose of the system is a changeable higher order principle that enables and guides the design of systems (Jones, 2014). Although the healthcare system purpose could be perceived as a persistent agreement, there could be discrepancies about how to achieve it (Barbero & Pallaro, 2017). These discrepancies are influenced by value conflicts, lack of common vision and priority of goals and outcomes (Haynes, 2018), so they should be consensually negotiated by the different stakeholders from the early stages of design (Jones & Bowes, 2017). Hence, it is critical to explore how to consensually define the purpose of the system in healthcare between multidisciplinary teams of stakeholders at the earliest stage of the design process.

Several systems thinking approaches rely on the use of visualisations to build consensus. Visualisations are graphical representations aiming to holistically communicate the relationship between the elements of the system. Historically, visualisations have helped to address the discussion of complex topics (Comi, Bischof, & J. Eppler, 2014; Crilly, Blackwell, & Clarkson, 2006) and to facilitate sensemaking from multidisciplinary perspectives complex systems (Holden et al., 2013; P. Jones & Bowes, 2016; Read, Salmon, Lenné, & Stanton, 2015). Despite those benefits, there are few methods that address the purpose definition supported by visualisations.

Among the system thinking approaches that aim to define the system purpose supported by visualisations are *Cognitive Work Analysis* (CWA) and *rich pictures*. CWA presents five different domains to map the system from purpose to values, functions, physical processes and objects (Rasmussen, 1985; Read et al., 2015; Salmon, Jenkins, Stanton, & Walker, 2010). The purpose domain is the highest level that defines the reason for the existence of the system, and it maintains a straightforward relationship with the values. CWA offers a structure of the expected visual output that comprises the five-domain definition prior to start further actions. However, it remains ambiguous how each of the domains should be addressed or whether how each of them could inform further design stages. In a related example, *rich pictures* is a soft system method that illustrates complex situations by connecting hand-drawn sketches (Bell & Morse, 2013). During the drawing process, not only traditional system components are incorporated, but also subjective and *hidden* elements such as prejudices, points of view and values are aroused. Rich pictures evoke a broad range of inner system issues, consequently, the visual result could be overwhelming to analyse and to apply as an input to further stages.

These systems approaches have offered insights into the importance of defining the purpose of the system while a system is going to be designed, but less attention has been paid into the practical aspects of facilitating the visualisation method. For example, to conduct a visualisation-based method often required a trained facilitator able to apply the tools or guide the process. It remains unclear how greater support can be provided to the facilitators that conduct visualisations as a mean to negotiated and define the purpose of the system. Traditionally, designers have occupied the role of facilitators and they could provide meaningful initial feedback on how they could be supported while conducting a visualisation method.

Therefore, the purpose of this study is to explore how designers visualise complex system interactions using healthcare outcomes to support the definition of a system purpose. This will provide an initial overview of the dynamics of a visual-based method towards the definition of better support elements to define the purpose of the healthcare system. To achieve this aim, the study conducted a visualisation-based workshop that employs a novel visualisation support tool.

2. Methodology

A three-hour workshop was conducted with a group of designers and design researches. The aim of the workshop was to explore how they visually conceptualise complex interactions between purposes, values and outcomes of a healthcare delivery system for diabetic patients. The structure of the workshop was adapted from general recommendations of Jones and Bowes (2016) Sevaldson (2015) and Skjelten (2014).

2.1. Participants and samplings

This workshop was arranged at an international Design conference (DRS2018). The attendees of this conference have the opportunity to participate in this workshop. The abstract of the workshop was posted in advance on the conference website allowing attendees to have an overview of the expected activities, major expected outcomes and gaining interested from those participants with previous experience in healthcare design.

The participant recruitment was achieve using a non-probabilistic sample of convenience with a space limit of twenty-five participants. Twenty-three design practitioners/researchers with experience in healthcare design participated in the final workshop. Smaller groups were formed through the first activity in the workshop by assigning participants randomly. The description of the participants is presented in Table 1.

Table 1. Descriptive information of the participants

Group	Number of participants	Professional Background	Experience in Healthcare
1	5	Academic, industrial design	Medical device design, assistive product, service design
2	5	Product design, Design research, industrial design	Relative living with, service design, design research, medical device manager
3	4	Academic, industrial designer	Service design
4	5	Product designer	Service design
5	4	Designer	User experience

2.2. Materials

Prior to the workshop, the research team prepared outcome cards (Figure 1) to facilitate group discussion and visual conceptualisation. The cards consist of two-sided 105x148 mm rectangles presenting a wide range of diabetes outcomes. On the front, the name of the outcome was written, while in the back part it showed a basic description of the outcome, tools to collect or monitor the outcome, the frequency of the collections and space for feedback.

Figure 1. Example of outcome cards used in the workshop (front and back)

Each team received thirty-three outcomes divided into five categories. The outcomes were selected based on a comprehensive literature review of the most relevant outcomes in diabetes care including patient-related, staff-related, organisation-related outcomes as well as clinical. Examples of provided outcomes are biometrics, health-related behaviours, safety, quality of care, subjective wellbeing and happiness. The outcomes included in the workshop are summarised in Table 2.

Another material was provided such as blank papers for individual visualisations, A0 blank paper for group visualisations, 5 cm round outcome stickers that contain the outcome name to facilitate their outcome mapping on the blank paper, markers and post-it notes.

Table 2. Outcomes included in the workshop of the preliminary study

Group	Outcomes included
Quality and Cost	Trust in physician, patient satisfaction, safety culture, adherence to clinical guidelines. Cost, hospitalisation
Comorbidities	Chronic kidney disease, functional status, depression, symptoms of complication, long-term complication, cognitive functioning, survival
Clinical	Hypoglycaemia, Diabetic ketoacidosis, HbA1c, blood pressure, cholesterol, risk factors,
Behavioural	Health literacy, self-care, adherence to treatment, physical activity, physical functioning, healthy lifestyle
Psychosocial	Health-related quality of life, happiness, social functioning, the economic burden of treatment, subjective wellbeing, perceived health status, diabetes distress, fear of hypoglycaemia,

2.3. Procedure

Pilot session

A pilot session was conducted to test the major activities of the workshop. This pilot session was held on month in advance on a different venue. Ten design researchers who were in their PhD programme were recruited.

One activity which asked the participants to analyse the existing outcome-based visualisations was dropped since it was found too time-consuming and overwhelming for the participants. In addition, an individual visualisation step was added. Participants mentioned that individual time was needed to familiarise with outcomes. The rest of the activities tested in the pilot session were considered appropriate and included in the workshop.

Final workshop

A design brief for visual outcome mapping and the aforementioned supporting materials were provided, but, no pre-defined template or rigid structure was imposed. This open mapping approach is similar to GIGA-Maps (Sevaldson, 2015; Skjelten, 2014), but outcome cards were additionally provided to facilitate the mapping process.

Participants were asked to carry out three main tasks. First, they were asked to generate an *individual* visualisation based on their first understanding of the outcome relationships. Second, they were asked to synthesise each perspective and to create one visualisation for each group. The group visualisations were basic models that represent the collaborative knowledge and agreements of the relationship of the outcomes. Finally, during the third activity participants were asked to produced oral narratives on their visualisations. They also provided feedback on the workshop activities.

2.4. Data Collection and Analysis

The visualisations were analysed based on the identification of the type of structures, frequencies of outcomes and other elements. The type of structure was identified by choosing the dominant structure that stands out the most from the visualisation. If more than one structure dominated the visualisation, both were identified and reported in the results. Afterwards, the visualisations were compared with each other to identify similar graphic patterns. Frequencies were also counted manually in each of the visualisations and the top five were reported.

In the case of narratives, the audios were transcribed and coded using an open thematic analysis following an inductive and critical realist perspective (Braun & Clarke, 2006). This perspective aims to report the experiences of participants but retaining the focus on the limits of reality. The thematic analysis allowed the extraction of the major themes mentioned by the groups. These themes are about how the participants used outcomes to define a purpose and how they used the materials provided. Coding was conducted using nVivo software.

3. Results

Overall, the data consisted of twenty-three individual visualisations and five group visualisations accompanied by their narratives. The results are presented in the following three sections: i) the analysis of the individual visualisations; ii) the group visualisations and iii) the thematic analysis of the narratives.

3.1. Individual visualisations

Each of the individual visualisations was analysed to find structure patterns, the frequency of outcomes and new elements added by the participants. Figure 2 shows an example of a mixed visualisation that illustrated a timeline and a location structure.

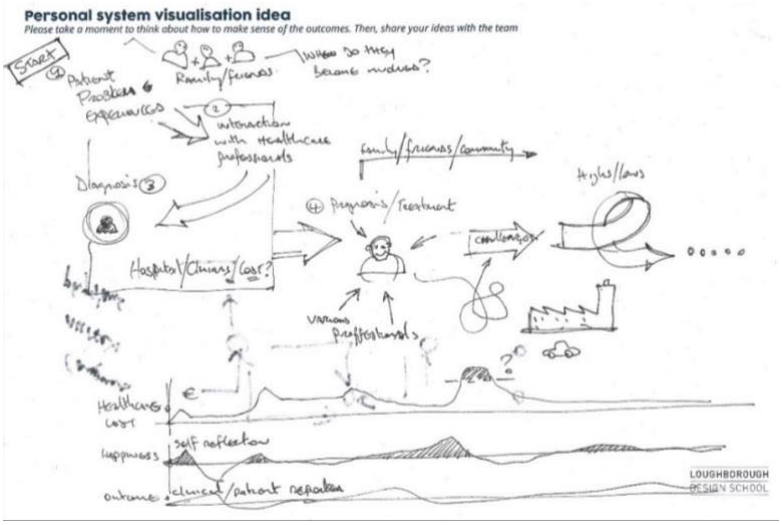
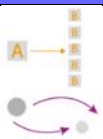
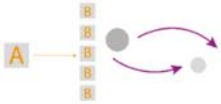


Figure 2. Example of individual visualisation

Table 3 summarises the findings from the rest of the individual visualisations. The results did no show a clear dominant structure among the participants, but timeline, location and intensity (arrange outcomes according to its importance and severity) were the three most common. Participants used this intensity structure to express outcomes changed over time.

Table 3. Types of structures in personal visualisations

Structures			
			
Timeline + location	Network + location	A to B (multiple) + Loops	Venn
			
Timeline + hierarchy	Clusters + Loops	Concept map + -Intensity	
			
Timeline + intensity + location	Clusters + intensity	A to B + Loops	
			
Concept map	Classification (symptoms, functions)	Patient-centred + intensity	
			
Classification (happiness)	A to B (multiple choices)	Concept map	

3.2. Team visualisations

Five team visualisations results (Figure 3) were analysed to identify the main structure, outcomes and relationships. The figure shows the individual structures on the top to compare with the group visualisation.

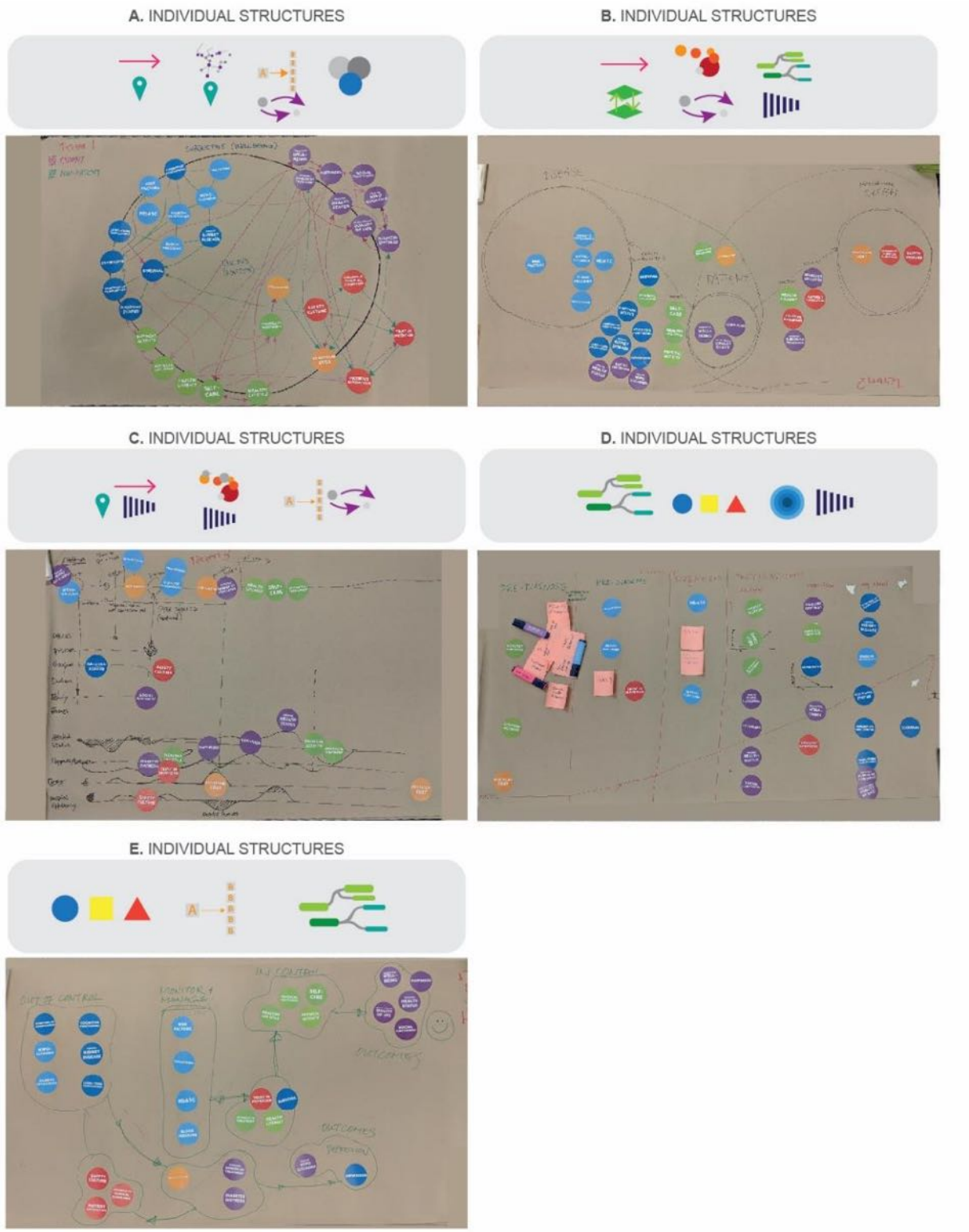


Figure 3. Team visualisations in contrast with the individual structures.

The most striking observation from the data comparison of the visualisations was the lack of a dominant structure across the five visualisations. A timeline appeared in two examples (C and D), but just in the example D the timeline structure dominated the visualisation. The timelines in example C were used to represent that outcomes are not statics and intensity fluctuations occur across time. Instead, circle, organic shapes and messy connectors (arrows) were preferred to represent the system. Interestingly, four out of five groups (A, B, D and E) generated completely new structures with respect to the individual visualisations. Only one of the group visualisations (C) was derived from a specific individual visualisation structure. This could suggest that the group visualisation process was not much influenced by the individual visualisation structure.

In four visualisations (A, B, D, E), outcomes were grouped and arranged into categories (Table 4). All the visualisations included outcomes from the five categories. But there were differences regarding which outcomes were included in the visualisation. Table 4 shows the percentages of the outcomes included in the group visualisation by five outcome categories. 100% indicates that all the outcomes provided of that category were included in the visualisation. Overall percentages were calculated considered the total of outcomes. These overall results show that behavioural and psychosocial outcomes tend to be more represented than the other groups. The group of quality and cost were less included.

Table 4. Management and percentage of use of outcomes in the group visualisations

Group	Categories created by each group	1. Quality and cost	2. Comorbidities	3. Clinical	4. Behavioural	5. Psychosocial
A	Patient and non-patient Objective and subjective	100%	100%	100%	100%	100%
B	Disease, patient and healthcare system	100%	100%	100%	100%	100%
C	No categories created	66%	14%	50%	83%	75%
D	Pre-diabetes, diagnosis and treatment	50%	100%	83%	100%	100%
E	Out of control, in contro and monitored	83%	86%	100%	100%	100%
Overall percentages		80%	80%	87%	97%	95%

3.3. Narratives on group visualisations

The thematic analysis of the narratives identified how participants used the outcomes and their opinions about how their visualisation can be applied in design. Three major topics arisen from the analysis are presented in Table 5.

Table 5. Main topics from thematic analysis

Theme	Comments from participants
How the outcomes should be/were used?	Outcomes should be continuously monitored rather than discussed once upfront.
	Psychosocial outcomes should be considered as long-term.
	Health status, happiness, cost and efficiencies were the most mentioned outcomes.
What did graphics represent?	Circle was used to represent continuous and organic process.
	Lines were used to segregate outcomes.
	Timelines were considered easy to use, but unhelpful in communicating complexity.
	Graphics should look messy to represent complexity.
How visualizations can be used in practice?	Visualisations are a great and simple tool (for designers) to identify correlations and improvement areas.
	Visualisations can help to solve conflicts between patient and providers.

Narratives clarified issues about the use of outcomes and the graphic conventions. Participants related psychosocial outcomes with long-term. These long-term outcomes also were linked to the *aim* of the system. Although it is not the same, participants used 'aim' and 'purpose' as interchangeable words. Participants mentioned that timelines (and lines, in general) did not communicate the messiness and the complexity of the system. Instead, participants alluded that circles, waves and organic arrows express the sensation of an 'unstructured' system. Finally, participants suggested that patients and providers could solve conflicts by doing a visualisation. Participants also declared that the material provided was an easy-to-use tool.

4. Discussion

The aim of the study was to explore the use of visualisations as a mean to define the purpose of the system. The results suggest that designers conceptualise complexity in different ways. Therefore, the outputs/visualisations could not be standardise. Nevertheless, the use of support elements (outcome cards) helped the participants to try different outcome arrangements. These outcomes arrangements evidenced how participants have negotiated the consensus during the workshop. Three findings emerged from this exploration: i) the lack of agreement between the group structures; ii) supporting material (outcome cards) was perceived very helpful and iii) some groups tend to quickly move forward design activities rather that purpose finding.

An unexpected finding of the study was the lack of a consistent structure among the five visualisations. Individual visualisations tended to use timeline and location structures. But the structures of group visualisations were completely different. The *purpose finding* tended to be related with the idea of the future. However, this future reference did not influence participants for using timelines. Some participants manifested that a timeline was too *simple* to represent the complexity of the system. Consequently, participants opted to express complexity through messy connections and organic circle structures.

None of the visualisation structures generated in this workshop were similar from CWA (Rasmussen, 1985) and other well-known design tools such as blueprints or journey maps. As this workshop recruit participants only with design backgrounds, a greater influence was expected from those widely-know design tools. Some individual visualisations, however, showed the similarity with rich pictures (Bell & Morse, 2013). These similarities denote the inclusion of sketches. These sketches could have been incorporated probably because drawing is a common designer activity. The resemblance with *rich pictures* was missed in the group visualisations. These group visualisations were lacking drawings. The discrepancies between the visualisations may suggest that participants visualise systems different when working in groups. Also, the lack of a pre-defined structure did not constrain the flow of the session; on the contrary, the open space encouraged the creativity of participants to generate visualisations with unexpected insights.

Consequently, the facilitation of the workshop played a vital role. Participants felt supported by the outcome cards in different ways. At the begging of the session, outcome cards were useful to 'break the ice' among participants, while in later stages, cards brought complex and meaningful issues into the discussion. Complex issues emerged when participants tried to relate apparently distant outcomes. To relate outcomes, participants created categories. These categories were different among the five visualisations, but psychosocial outcomes were related with the long term and with the patient expectations.

Participants needed to holistically comprehend the outcomes prior to relate them. Therefore, participants evoked personal experiences to complete the understanding of outcomes. The changes in the understanding of outcomes were evidenced by how participant moved the outcomes. Participants moved the outcomes around the surface trying to integrate insights from all the participants. This type of function could be considered analogous to the role of a boundary objects (Star & Griesemer, 1989).

Boundary objects are a common ground *interface* to help communities of practice to translate idiosyncratic meanings towards a better collaboration. The boundary objects should be *flexible* enough to be adapted by participants to different situation (Sajtos, Kleinaltenkamp, & Harrison, 2018; Star & Griesemer, 1989). Previous research in organisational sciences have proposed that boundary objects enable consensus-based interprofessional collaboration (Fominykh, Prasolova-Førland, Divitini, & Petersen, 2016; Sajtos et al., 2018); in addition, similar benefits have been found in healthcare practices (Keshet, Ben-Arye, & Schiff, 2013b; Sampalli, Shepherd, & Duffy, 2011). In this study, the outcome cards took the role of a boundary object. The *flexible* component emerged from the disagreements about the meaning and importance of outcomes. Psychosocial outcomes such as happiness, wellbeing and quality of life still are facing disagreements about their meaning and importance. These disagreements were used as provocations to discussion overarching elements of the system such as the purpose and values. This indicated that an open visualisation process could be positively supported by the implementation of a boundary object. A boundary object could enhance the communication of the participants and guide discussions to negotiate complex issues.

Finally, it was important the tendency of designers to move forward the design process. During the workshop session, participants were immersed in the activities of the purpose definition. But participants also showed hesitation because of the lack of a design application in the instructions. Consequently, participants related the visualisations with a practical design implication such as service design. The rush to jump into the next stage should be balanced by encouraging a slower and deeper reflection. Bell & Morse (2013) also identified that as soon as *problems* were spotted on the rich picture, participants are encouraged to move to the next step. This quick progression of the process leaves behind the richness of the picture. Nevertheless, this observation needs further research to define a balance between reflection and practical development.

Limitations

The scope of this study was limited in terms of the group of participants focusing exclusively on designers. This could have an influence on the perceived confidence to develop the activities. Designers normally feel comfortable dealing with the graphic-related assignment, but it remains in doubt how the rest of the healthcare stakeholders react to this visualisation method. A natural progression of this work is to explore the use of visualisation with patients and providers.

5. Conclusions

In summary, this study aims to explore how designers visualise complex systems using healthcare outcomes. The study illustrated that complexity could be graphically conceptualised different across participants. Individual structures were radically transformed into unique representation by group discussions. Groups found challenged to express complexity through graphic conventions such as timelines and appreciate the graphic flexibility of the expected output. This workshop also reflects that an open-based visualisation could engage participants in the task of discussing complex topics and solving conflicts. This study also shows that the use of support could be highly beneficial to conduct an open visualisation session. Outcome cards, as supported elements, were a promising support for modelling healthcare systems.

Further research needs to be conducted to compare these results with patients and providers. The comparations would verify if the structures and the process could be analogous. This further study could also contribute to developing a system thinking method to deal with value conflicts in healthcare. More research is also needed to study in detail the role of outcome cards as boundary objects. This progression could transform the cards into a feasible ‘common language’ to visualise healthcare systems. Potential opportunities arise from exploring interactive artefacts to promote different arrangements and relationships.

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