The Role of Human and Organizational Factors in the Pursuit of One Digital Health

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Summary

Objective: This paper surveys a subset of the 2022 human and organizational factor (HOF) literature to provide guidance on building a One Digital Health ecosystem.

Methods: We searched a subset of journals in PubMed/Medline for studies with „human factors" or „organization" in the title or abstract. Papers published in 2022 were eligible for inclusion in the survey. Selected papers were categorized into structural and behavioural aspects to understand digital health enabled interactions across micro, meso, and macro systems.

Results: Our survey of the 2022 HOF literature showed that while we continue to make meaningful progress at digital health enabled interactions across systems levels, there are still challenges that must be overcome. For example, we must continue to grow the breadth of HOF research beyond individual users and systems to assist with the scale up of digital health systems across and beyond organizations. We summarize the findings by providing five HOF considerations to help build a One Digital Health ecosystem.

Conclusion: One Digital Health challenges us to improve coordination, communication, and collaboration between the health, environmental and veterinary sectors. Doing so requires us to develop both the structural and behavioural capacity of digital health systems at the organizational level and beyond so that we can develop more robust and integrated systems across health, environmental and veterinary sectors. The HOF community has much to offer and must play a leading role in designing a One Digital Health ecosystem.

Keywords

Organization and Human Factors interactions, one digital health structures, behaviours

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1 Introduction

Human and organizational factors (HOFs) are important contributors to biomedical informatics research and education. HOFs encompass both human factors and organizational factors and while those two entities are distinct fields, they are complementary to one another. Human factors and ergonomics (HFE) focus on the study of human work systems to better understand the interactions between people and their systems of work, including organizational factors, so that technology fits and is aligned with the context and behaviours of work as intended to be done, rather than technology driving how work is done [1, 2]. At the same time, there is growing need to understand the diversity of organizational factors that span micro level issues such as workflow and communication models to meso and macro level factors (such as change management, politics, and leadership) so we can better understand how organizational factors impact health information technology (HIT) implementation and usage within a setting [3-5].

A common thread between HFE and organizational factors is a focus on the overall system where HIT is used. One Digital Health (ODH) is the intersection of One Health and Digital Health that integrates the holistic view of One Health (i.e., human health, animal health, and the surrounding environment) with the various aspects of digital health including the collection and storage of information and its use to enable personalized care delivery and the pursuit of broader human and population health goals [6]. While ODH is a new concept, it represents a variation on systems thinking, an approach that describes the interactions across system components to understand system behaviour over time [7-8]. Systems thinking has been used in biomedical informatics research to study aspects of health delivery including information complexity, the way in which different types of complexity impact HIT over time, and complexity in environments like critical care [9-12]. The value in systems thinking is that it allows us to look beyond any one system concept to better understand the myriad of system concepts and how they interact with each other and evolve over time.

A challenge in studying HOFs is that they are abstract and may not be directly visible in the day-to-day use of digital health tools. HOFs often present themselves as unintended consequences of HIT implementation such as workflow, communication, or power issues [13]. It has been advocated that we need to find ways to help visualize and frame HOFs to make them more explicit and easier to study in a particular context [14-15].

Over time we have seen an evolution of HOF studies from reactive to proactive to enable us to incorporate HOFs into the upstream design of digital health tools rather than reacting to the emergence of unintended consequences. An example of the evolution of HOF studies is the Systems Engineering Initiative for Patient Safety (SEIPS) model developed by Carayon *et al.* [16]. The initial SEIPS model was designed as a framework to improve our understanding of the system factors that contribute to patient safety, while latter iterations of the SEIPS model have evolved such as including the concept of the patient journey to describe the spatio-temporal distribution of patients' interactions with multiple care settings over time [17].

A key focus of HOF studies is on how different users interact with HIT and the range of organizational and other contextual factors that influence these interactions [14, 18]. While the study of these interactions can include human factor and usability considerations at the human-technology interface, they can also include the broader micro, meso, and macro systems beyond the individual user-technology interface. In fact, we are seeing more attention being paid to the broader systems where HOFs exist and the need for systems thinking approaches to help understand how technology and users interact [11, 15]. ODH is the integration of human, environmental and animal ecosystems and our ability to implement ODH will only be as good as our ability to enable meaningful interactions across various users, settings, and sectors and to help these interactions evolve over time. To that end, the HOF community can play a key role in developing a ODH ecosystem by enabling interactions across system sectors.

This paper surveys a subset of the 2022 HOF literature to provide guidance on building a One Digital Health ecosystem. The forthcoming sections describe the method for how we obtained and analyzed the literature. We then present the results of our survey where we characterized the literature according to structures and behaviours followed by an integration of the findings as HOF considerations for building a ODH ecosystem.

2 Methods

Drawing on the approach and style of previous years' HOF review papers (e.g., [2]), we surveyed literature published in 2022 to identify papers studying HOFs. As ODH is a new concept there are very limited papers on ODH and HOFs and a survey of that topic was not possible. As described above, the ODH ecosystem is about digital health enabled interactions across human, environmental, and animal ecosystems. The means by which we enable interactions across micro, meso, and macro levels will be crucial to the success of ODH, and the HOF community can make a key contribution to helping build this capacity. Therefore, we focused our survey on literature that provided HOF perspectives on digital health enabled interactions at micro, meso, and macro levels.

We reviewed journals affiliated with the International Medical Informatics Association (https://imia-medinfo.org/wp/publications/), the following journals were surveyed: Applied Clinical Informatics, Informatics for Health and Social Care, International Journal of Medical Informatics, Journal of the American Medical Informatics Association, and the Journal of Biomedical Informatics. We also surveyed the Journal of Medical Internet Research and the proceedings of the American Medical Informatics Association (AMIA) Annual Symposium. We searched the above journals and the AMIA Annual Symposium proceedings in PubMed/Medline for studies with "human factors" or "organization*" in the title or abstract. Papers meeting the above criteria and published in 2022 were eligible for inclusion in the survey.

Analysis of Findings

While our interest was in understanding digital health enabled interactions across micro, meso and macro systems, we wanted some explicit means to characterize and describe the interactions. Fig. 1 shows how the papers were analyzed. We first analyzed the surveyed papers to understand the different digital health enabled interactions at micro, meso, and macro levels. We then drew on previous HOF research that described the need to characterize and define the structural and behavioural aspects that enable interactions across people, technology, and processes at micro, meso, and macro levels [15,18]. Structures and behaviours provide an explicit means of labelling and understanding HOF issues at micro, meso, and macro levels. Therefore, papers were manually categorized into structural and behavioural aspects to understand the types of structures that enable interactions but also how user behaviours influence and define how the structures are used and adapted in different settings and contexts [19].

3 Results

Below we present our survey of the 2022 HOF literature categorized according to structures and behaviours followed by an integration of the findings as HOF considerations for building a ODH ecosystem.

3.1 Structures

Structures refer to people, processes, and technologies and how they are integrated as part of a digital health ecosystem [19]. Structural configuration may describe different types of users (e.g., patients, providers, administrators), technologies (e.g., electronic health record (EHR) or personal health record (PHR)) or care delivery processes or modalities (e.g., communication, decision support, synchronous vs asynchronous) and how they interact as part of care delivery at and across micro, meso, or macro levels.

As expected, our review saw a range of studies focusing on different technologies and across different system levels. Many of the surveyed papers studied HOFs using specific technologies including mental health consultation [20, 21], online consultations [22, 32], clinical decision support systems (CDSS) [23], electronic medication management systems [24], video consultation [25-26], aged care systems [27] and telemedicine [36]. The context of use for these systems included hospitals [23, 28-34], residential aged care homes [27], and community health facilities [35]. Eleven papers were review papers and described a range of technology, users, and processes [20-22, 26-27, 31, 37-41].

Some papers also described systems that could be classified as complementary structures in that they supported other processes. Abraham et al. studied an anaesthesia control tower that remotely monitors surgery to assist with supporting factors such as situational awareness as part of reducing potential errors or other adverse events [46]. Komenda et al. developed a control centre for ICU monitoring that provides information on capacities of intensive care in real time as well as a module for online entering and overall record-keeping of requirements on medications for COVID-19 patients [33].

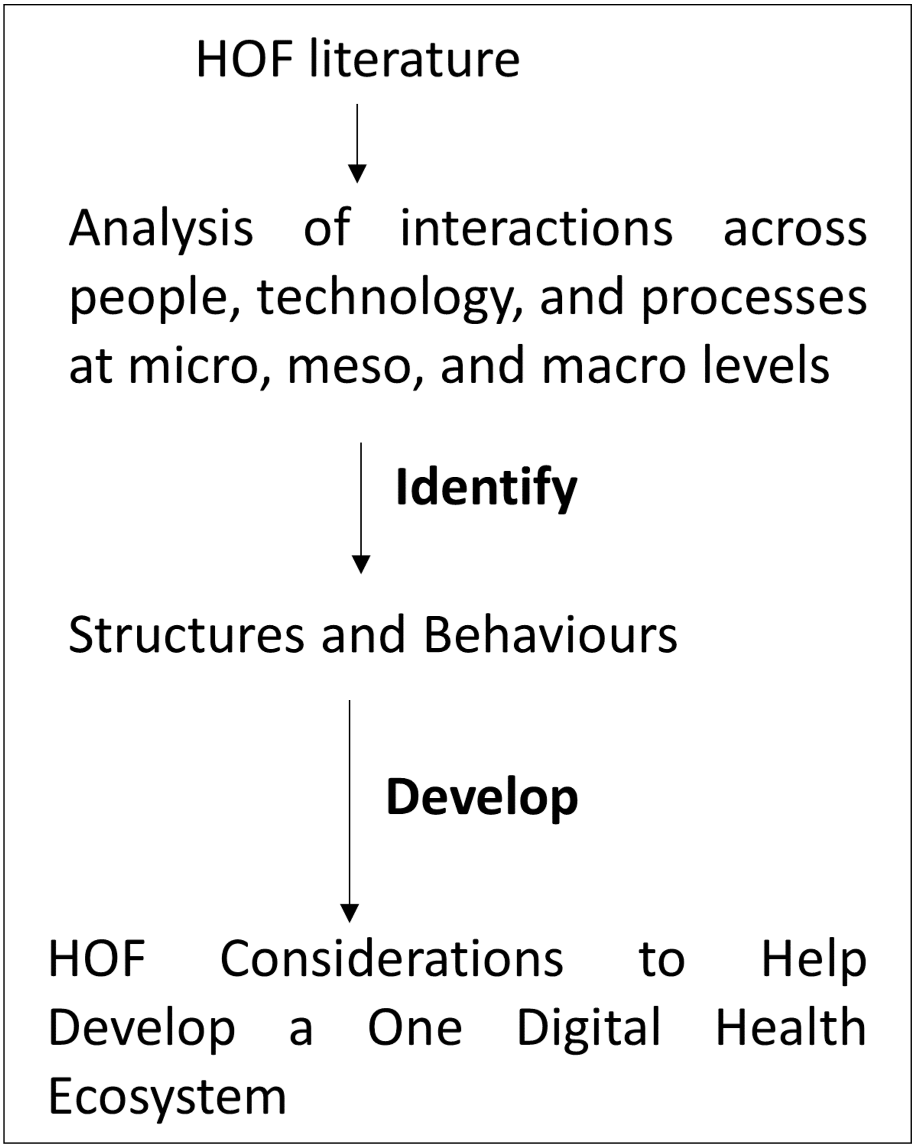

Fig.1 Conceptual model for analysis of surveyed papers.

Elkefi reviewed the use of digital twins, defined as twinned systems, processes, and/or products, and how they can expand digital health capacity by providing supplementary support for tasks such as safety management, information management and operational control [37]. Abasse et al., described a collaborative writing application (CWA) that provided flexible support for knowledge management or for monitoring disease progress during the COVID-19 pandemic [39].

Classic user-technology interface issues such as usability continue to be a focus of HOF studies [23, 26, 27, 34, 42, 45]. While individual user factors play a part in system related errors, so do organizational and other contextual factors [24], highlighting the need to evaluate system structures beyond the level of the individual user interface. HIT may provide satisfactory support for collaboration and information exchange between professionals in the same organization but can be problematic when scaled up to cross-organizational collaboration, and information exchange [42]. Pullman et al. showed that an electronic clinical quality measure (eCQM) varied by state and organizational level policies [43].

While some structural elements (e.g., technology) are fixed at a point in time, other structural elements that interact with technology (e.g., people and processes) can evolve over time. Woods *et al.* [44] described the need to accommodate digital health maturity through development of a Digital Health Infrastructure (DHI) across four dimensions: governance and workforce; interoperability; person-enabled health; and predictive analytics. Their study also highlighted how digital health maturity can evolve unevenly and that dedicated attention must be paid to development and monitoring of all health maturity dimensions.

Finally, The HOF community continues to develop principles or approaches for systems design that proactively address HOF issues. Solomonides *et al.* [47] developed a set of principles for engagement with Artificial Intelligence (AI) and for continued evolution of AI in biomedical and healthcare applications. Bedoya *et al.* [48] identified a gap where AI or machine learning models are developed without due attention to clinical or operational impact. To address that issue, they developed a framework that combines current regulatory best practices and lifecycle management of predictive models being used for clinical care. Data journey modeling was used a means to better understand sociotechnical barriers as part of our pursuit of digital transformation [49]. The Consolidated Framework for Implementation Research (CFIR) Approach was adapted into an optimization methodology that that helped manage organizational change due to EHR implementation through organizational optimization of clinical and operational workflows [50].

3.2 Behaviours

Behaviours describe how a structural triad of people, processes, and technology works in a specific setting or context. A particular focus of system behaviours is how people and processes evolve in their use of digital health over time and how system behaviours present across micro, meso, and macro levels.

3.2.1 Micro

The micro level refers to individual behaviours and interactions with HIT as part of care delivery or other health service-related tasks. As mentioned above, while individual usability and human factor issues remain a focus of HOF research, research is starting to explore how addressing these issues requires purposeful attention beyond the individual-technology interface. Viitanen *et al.* [42] highlight an important point in that usability and human factor studies must be done with all user groups that will be using an HIT system owing to different system behaviours by different users. Their study showed that social welfare professionals scored a system more favourable than physicians or nurses due to the fact the latter two professions have a more hectic work environment including higher documentation demands [42]. Zhai *et al.* [23] used the Fit between Individuals, Task, and Technology (FITT) framework to study CDSS implementation across nurses and found that while user resistance and usability are core issues to manage, doing so goes well beyond the user-technology interface and included system-related, user-related, and organizational factors. Hilty *et al.* [31] state how we need to be more purposeful in designing technology that helps implement the Quadruple Aim goals such as clinician burnout and doing so requires a multilevel approach that targets multiple factors including clinical, human factors, training, professional development, and administrative workflows. Harahap *et al.* [35] found that while individual factors such as perceived usefulness and ease of use are important facilitators of personal health record adoption, so are broader factors such as digital literacy. Other studies also emphasized the need to study HOFs across a broad range of user behaviours as factors such as digital and health literacy can impact user interactions with HIT and will vary by group [26].

While most of the surveyed papers focused on clinicians, we continue to see studies assessing system behaviours of patients and other user groups. Wang *et al.* [38] defined the digital patient experience as "the sum of all interactions affected by a patient's behavioural determinants" recognizing that patients may have different motivations or expectations for HIT supported therapy. When looking at system behaviours beyond an individual group, we must account for the fact that different users may have different expectations for how HIT should be used. Holmgren *et al.* [51] showed that COVID-19 led to more patients using telemedicine, which increased clinicians workload because of great messaging and other communication from patients. The degree and modality (e.g., video, phone, asynchronous messaging) of telemedicine-enabled communication must be negotiated across different user groups. Bail *et al.* [27] studied HIT in residential care homes and found that while usability and system acceptability were well covered at a clinical level, there is a need to expand outcomes to quality and safety of residents and their families.

Some papers presented innovative approaches for understanding and helping understand micro level system behaviours. Hueget *et al.* [32] studied economic viability of a teleconsultation system and showed that attention must be paid to characteristics of the system's users, as it influences system performance and outcomes such as cost-efficiency. Their approach used a novel discrete simulation system to better understand user scenarios and how different system configurations impact economic outcomes of the system [32]. Cifra *et al.* [34] developed a semiautomated electronic feedback system that delivered timely and relevant pediatric intensive care unit (PICU) patient outcome feedback to referring ED physicians. The ED physicians appreciated the opportunity to learn from the feedback and stated the feedback process was well integrated into their clinical workload.

3.2.2 Meso

The meso level is where system behaviours and user interactions extend beyond individual users into organizational systems, including how individual tasks scale into team-based tasks. Some of the surveyed papers described how individual level requirements transitioned or scaled up to team or other organizational level settings. Of significance is that these papers continue to highlight the importance of understanding the bigger system of processes, tasks and other system concepts that exist outside the user-technology interface. Barriers and facilitators to CDSS implementation included system-related, user-related, and organizational factors [23]. Individual-centered interventions are not enough, and they must be complemented with organizational focused interventions [23]. Harahap studied personal health record adoption in Indonesia and showed that while individual and technological factors impact PHR adoption, so do organizational factors [35]. Scale up of video consultations requires a mix of top down and bottom-up approaches to ensure systems have technical dependability but also are aligned with the social and cultural context where they will be used [25]. Mitigating negative unintended consequences from online consultation systems requires integration with the technical systems (e.g., software) and with organizational workflows [22].

Organizational strategies for clinician engagement are one means of understanding and preventing burnout and other adverse outcomes. Sung *et al.* [26] suggest that internal HIT factors and external human factors at the organizational level both influence HIT implementation and it is important to understand both these perspectives. An organizational-level EHR strategy supports an understanding of evolving needs and sentiments of clinicians as a precursor to mitigating issues such as burnout [53]. Similarly, a Physician Engagement Strategy with four components: engage, inspire, change, and measure was developed to reduce the burden of EHR use on physicians [28]. Chen *et al.* [29] highlighted how developing clinical informatics competencies at the organizational level is needed to complement individual level competencies.

HIT is often designed and evaluated from the perspectives of individuals, but we are increasingly seeing more care delivered via teams. A key meso level behavioural issue is the movement from individual to team based or collaborative tasks. An issue is that HIT may work well at the individual level but encounter scalability issues when it must support collaboration or teamwork [42]. While frameworks such as the FITT framework evaluate the individual user-technology interface they do not adequately assess HIT support for interdisciplinary collaboration [23]. When HIT fails to adequately support teamwork we see workarounds or manual processes such as for data transfer or other tasks, which leads to a significant administrative burden on clinical teams [50]. While we often transition or scale processes from the micro to the meso level [49, 53], we can also use blended approaches that start at the team or organizational level and then scale down to individuals [25, 49].

Despite the above issues on moving from individual to team-based care delivery, it is comforting that studies have started to address the need for HOF research to look at the scale up of individuals into teamwork. Carayon *et al.* [53] highlight an important factor in that team-based care delivery needs to be factored into system design and that incorporating HFE principles into design can help develop usable technology that support diverse care teams. Similarly, Guilabert *et al.* [54] developed a tool to assess fundamental aspects of multi-disciplinary care teams including collaboration and communication, leadership, and the organizational environment.

3.2.3 Macro

The macro level is where the micro and meso levels scale to policy, funding, human resource, and other macro level system factors. A study of eHealth adoption in India identified several barriers, many of which were macro system issues including customer engagement, and customer loyalty, literacy in eHealth, lack of motivational value for elderly people, unclear benefits, lack of trust, and cultural ethical challenges [55]. A key shortcoming was highlighted in a review of telemedicine policies in China where they found most of the existing policies were related to platform construction and other technical elements with far less policies on how the structural elements were used to enable care delivery such as service operation and application and organizational management [36]. While scalability issues across all system levels are common and often present as problematic [25], system scalability when done properly can provide positive benefits. Creative Writing Applications offered scalability and adaptability benefits that accelerated achievement of macro level goals like knowledge translation and knowledge management during the COVID-19 pandemic [39].

ODH is about broader health system goals such as coordination and communication, but system design often focuses on support for micro level tasks and outcomes such as efficiency. Broader system level outcomes as patient safety, enhancement of team-based care, and prevention of provider burnout will not be achieved unless we explicitly design and evaluate systems to support those goals [28, 31]. Prevention of provider burnout and fatigue has to go beyond the design of technology at the individual level and must be evaluated with macro goals like the Quadruple Aim in order to support providers‘ well-being and to prevent workload burden, fatigue, and burnout [31]. Implementation and a multi-level design approach with objective measures for clinical, human factors, training, professional development, and administrative workflow are needed for the realization of macro level outcomes [31]. We also need to appreciate that while HIT may be designed for a certain purpose, it may need to be adapted to move from supporting micro level behaviours such as efficiency to macro level outcomes such as safety [25]. We must get into a mindset for digital health design that considers the broader ecosystem where digital health is used such as supporting regional interoperability at the macro level and specialty-specific views of data to support multi-organizational clinical services at the micro level [35, 39, 44, 50].

Some studies provided approaches to understand the transition across sectors to achieve macro level goals. Data science was suggested as a means of developing Research Patient Data Repositories that go beyond machine-readable standards by also focusing on the integrated data industry view [56]. Big data technology could assist the development of medical collaborative networks that support care delivery across organizations [57]. Richardson *et al.* [58] advocated for regional cooperatives to develop electronic clinical quality measures (eCQMs) because they determined neither EHRs alone nor centralized data sources alone could operationalize eCQMs. Cooperatives enabled economies of scales for solutions and resources that often are unavailable to small-to-medium-sized practices.

Bhattacharyya *et al.* [59] highlight an important issue in that while we need to support innovation in health care delivery, hospitals and care delivery centres focus on day-to-day care delivery, which is distinct from exploring new services or care delivery models. They suggest that an innovation agenda requires different incentives for how to build internal capacity and measure success.

3.3 HOF Considerations to help build a ODH Ecosystem

We summarize the reviewed literature by identifying a set of five HOF considerations to help build a ODH ecosystem (Figure 2). The considerations emerged out of the findings from our survey. While several HOF issues were identified in this paper, we focus on the five HOF considerations that we believe will provide the best quick wins for moving ODH forward. The five HOF considerations are not linear or stand alone but rather are embedded across each other and the micro, meso, and macro systems where HIT is used.

1. **Enabling and Monitoring System Maturity** - While digital health tools are implemented at a point in time, the system structures, and behaviours that are enabled by the tools will continue to evolve over time [44]. As ODH capacity develops it will bring with it new system requirements and these must also be factored into the existing systems in the health, agricultural and environmental sectors. However, our pursuit of ODH will not be successful if we solely focus on developing system structures rather than defining and supporting the range

of system behaviours that will interact with the structures. System structures and behaviours must be co-designed as a symbiotic system.

2. **Sustained User Engagement is Essential** – The first rule of HOF studies is put the users in the centre of the design and then other aspects will fall into place. This is a challenging time for global health systems as the COVID-19 pandemic continues to disrupt health systems worldwide. HIT induced burnout was a challenge before the pandemic and it only got worse because of it. ODH will only be as successful as how we engage with users of all types including patients, providers, and administrators in the heath sector and similar users in the environmental and veterinary sectors. Some of the surveyed papers provided examples of engagement strategies [28, 53] and we should look to these as a starting point for engagement strategies while expanding and scaling where need be.
3. **Team Based Competencies Must be Developed** – A common theme in our survey was the challenge in moving from individual to team or collaborative tasks [25, 44, 49, 53]. On one hand, ODH really is collaborative care delivery at a very large scale, but we cannot design and evaluate collaborative systems from an individual user perspective and expect it to scale up to support team-based care. The individual-collaborative interchange that describes the movement from individual to team-based tasks must be explicitly accounted for in systems design and evaluation [15]. As we develop a ODH ecosystem it will increase the scale of collaboration across institutions and sectors and team-based system behaviours must be developed as part of growing system-based competencies such as integrated data and communication systems.
4. **Separate out Innovation from Day-to-Day Operations** – The need to support innovation was emphasized in some papers (e.g., [25, 32]) but it was pointed out that innovation is a different process from day-to-day care delivery tasks [59]. System design to support day-to-day care delivery is more purposeful while innovation is more exploratory and may have different goals and outcomes. ODH is a very ambitious endeavour that will require an interdisciplinary system design mindset and focused time in the design sandbox. System innovation and a learning health systems mindset will be key building blocks of ODH. We will need to find the balance between providing necessary digital health support for day-to-day care delivery and operations and for pursuing the design of innovative systems.
5. **System Design to support HOFs must be Purposeful and Explicit** – HOFs have long been an invisible aspect of digital health systems. Our review described how telemedicine has policies to govern technical aspects of a telemedicine system but far less policy development to govern the operational management and organizational aspects of the system [36]. We cannot implement a ODH ecosystem and hope for the best with respect to HOFs as such a plan will lead to unintended consequences and user dissatisfaction. ODH requires purposeful design to support the interactions needed for it to succeed. We must leverage the substantial body of HOF research that already exists to purposefully design a ODH system that proactively accounts for HOFs.

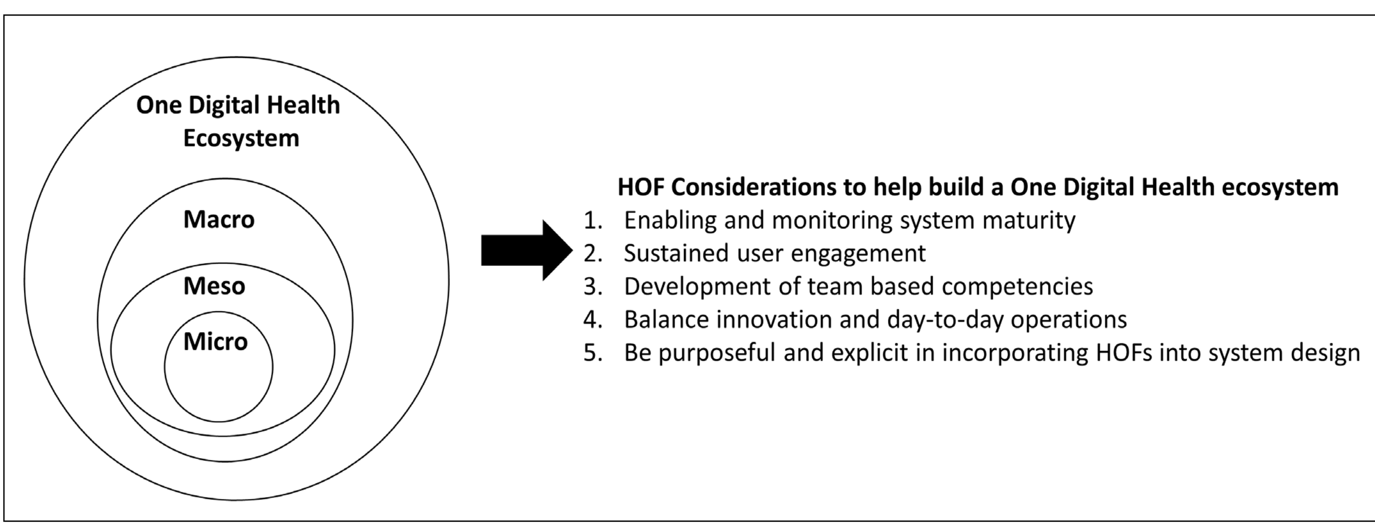

Fig. 2 Human and Organizational Factor Considerations to help build a One Digital Health ecosystem.

4 Discussion

Our survey of the 2022 HOF literature highlighted a range of studies that provided valuable insight for helping grow One Digital Health (ODH) capacity. HOFs are essential pieces for the design of a safe and efficient healthcare system [60], and this paper provided direction for doing that by reviewing digital health enabled interactions at micro, meso, and macro levels and then characterizing the interactions from the perspective of system structures and behaviours. HOFs must be studied upstream in the system design process so they can be properly characterized and incorporated into the design process. Our survey affirmed that we need to pay attention to both the structural and behavioural aspects of digital health systems as the user behaviours that interact with system structures are a key part of building a sustainable digital heath ecosystem. User behaviour and organizational needs emerge over time and ongoing understanding and managing them must be a purposeful part of systems design. ODH challenges us to improve coordination, communication, and collaboration between the human health, environmental, and animal systems [6]. Doing so requires a shift from siloed systems focused on one sector to those that can move seamlessly across micro, meso, and macro levels to strengthen the overall ODH ecosystem. Our survey showed that while we continue to make meaningful progress at enabling interactions across systems levels, there are still challenges that must be overcome. For example, we must continue to grow the breadth of HOF research beyond individual users and systems to assist with the scale up of digital health systems across and beyond organizations. It is inspiring that our survey of HOF literature showed a growing body of research on understanding system behaviours at the organizational level and beyond so that we can develop more robust and integrated digital health systems across micro, meso, and macro levels. Overall, our pursuit of ODH will require innovative approaches for individual and public health delivery while also requiring us to develop an integrated ecosystem across human health, animal health, and surrounding environmental systems.

ODH is an ambitious effort to create an integrated global health system. It may be a new concept but the notion of connecting different agents (e.g., patients, practitioners, policy makers) across disciplines and settings is not new. To that end, ODH is not immune from HOF issues such as those described in this paper. ODH challenges us to think beyond health systems by bringing in the need to integrate environmental and veterinary ecosystems, but this expansion brings with it new interactions and communication and data exchange needs across micro, meso, and macro levels. ODH will not be realized by broad macro level strategies that are not sufficiently grounded in the day-to-day tasks and front-line context where health, veterinary, and environmental services are delivered. Delivering on the potential of ODH will require a dedicated effort to study and manage HOFs as part of system design.

Our categorisation of the HOF literature into structures and behaviours provides a practical means of understanding the range of HOFs that exist, but it also highlights the need to pay attention to the interactions between the structural and behavioural aspects of digital health systems. While our initial starting point for digital health systems often focuses on structural aspects like data and technical architecture, it is important to remember that structural capacity on its own will not deliver desired ODH outcomes. Due attention must also be given to developing the necessary system behaviours that are needed to deliver on the promise of ODH. Failure to properly understand the behavioural aspect of digital health interactions are what leads to unintended consequences and other undesired outcomes.

While many HOF related issues were identified in the paper, we developed a set of five considerations that should be our initial focus for moving ODH forward. Scalability was a common theme in our survey and will be a significant challenge in building a ODH ecosystem. We must continue to make progress in developing team-based competencies across organizations and sectors while also ensuring we support the needs of the various micro level systems that exist. Health systems are social structures that evolve through a system of positive and negative feedback loops. If we can understand how macro level system needs influence digital health usage, we will be better able to account for how individual system behaviours develop and evolve over time. This would allow to better account for and manage the development of the system interactions that will be needed to develop a ODH ecosystem.

Limitations of this paper are that we only surveyed a small cross section of studies from a subset of journals. We also focused on system structures and behaviours, and it is likely that some HOF perspectives on the topic were missed. Other HOF perspectives on ODH is a needed area of future research.

5 Conclusions

This paper surveyed a subset of HOF papers from 2022 from the perspective of system structures and behaviours to understand how the HOF community can help build a ODH ecosystem. Development of a ODH ecosystem requires a dedicated effort for building an integrated ecosystem across health, environmental and veterinary sectors and how ODH enables meaningful interactions across these sectors will be an essential part of its growth and success. The results from the survey were summarized as a set of HOF considerations to support digital health enabled system interactions and include the need to monitor system maturity, develop collaborative capacities, and to be explicit and purposeful in how we identify and incorporate HOFs into systems design to support integrated digital health systems.

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