



Wise Wearables

A model framework for building innovation ecosystems for disruptive technologies in healthcare

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Abstract

Title: Wise Wearables - A model framework for building innovation ecosystems for disruptive technologies in healthcare

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Macroenvironmental factors such as aging societies, with longer lifespans and increased prevalence of co-morbidities are increasing spend and strain on the healthcare system. If these trends continue unchecked, health systems will face serious repercussions to access to and quality of healthcare. To combat macroenvironmental trends, different health technology experts from WHO, WEF, and EU are calling for a shift in health culture from diagnose and treatment to prevention and health maintenance. One technology that potentially holds the key to this cultural shift is the cluster of wearable technologies. The aim of this study was to depart from the acknowledgement that recording of biometric data, or other functionalities, via wearables can aid users and populations in achieving disease prevention and health promotion, and if so, to formulate a model to guide the orchestration of such a technology into the healthcare system. Both the hypothesis of the potential efficacy of wearables and the validity of a formulated framework (Wise Wearables) was explored with subject matter experts in qualitative interviews. The conclusions from this work are that wearable technology has the potential to impact disease prevention and health management if there is alignment and collaboration between stakeholders, appropriate mechanisms utilized, and key adoption approaches taken. The Wise Wearables framework was also subsequently refined because of the interviews. Disruptive innovation needs to take place not only regarding wearable technology, but also with members of its ecosystem. The proposed Wise Wearable framework provides a conceptual roadmap on bringing digital health technologies from ideation to reality.

Keywords: Healthcare, digital transformation, health prevention and maintenance, wearables, framework, Wise Wearables, innovation, ecosystem, population health, individual health, disruptive health technologies, adoption

Abstrato

Título: Wise Wearables - Um quadro modelo para construir ecossistemas de inovação para tecnologias disruptivas nos cuidados de saúde

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Os factores macro-ambientais na saúde, tais como uma maior duração de vida e uma maior prevalência de co-morbilidades, estão a pressionar a sobrecarregar o sistema de saúde. Se estas tendências continuarem sem controlo, os sistemas de saúde enfrentarão repercussões no que diz respeito ao acesso e à qualidade dos cuidados de saúde. Uma solução holisticamente benéfica para contrariar as marcas macroambientais propostas pela OMS, O WEF, e o EXPH apelam a uma mudança na cultura da saúde, de diagnóstico e tratamento para prevenção e manutenção. O objectivo deste estudo era determinar se o registo de dados biométricos através de objectos de uso pode ajudar os utilizadores e as populações a alcançar a prevenção e manutenção da saúde e, em caso afirmativo, formular um modelo para orientar a orquestração de tal tecnologia no sistema de saúde. Tanto a hipótese da eficácia das vestes como a validade de um quadro formulado (Wise Wearables) foram testadas com 13 peritos em entrevistas qualitativas. As conclusões deste trabalho incluem que a tecnologia vestível tem o impacto potencial de prevenção e gestão da saúde se houver alinhamento e colaboração entre as partes interessadas, mecanismos apropriados utilizados, e abordagens chave de adopção adoptadas. O quadro do Wise Wearables foi também posteriormente aperfeiçoado devido às entrevistas. A inovação disruptiva tem de ocorrer não só no que diz respeito à tecnologia wearable, mas também com membros do seu ecossistema. O quadro Wise Wearable proposto fornece um roteiro conceptual para levar as tecnologias digitais de saúde da ideação à realidade.

Palavras-chave: Cuidados de saúde, transformação digital, prevenção e manutenção da saúde, artigos de desgaste, estrutura, Wise Wearables, inovação, ecossistema, saúde populacional, saúde individual, tecnologias de saúde disruptivas, adopção

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Abbreviations

DHT: Digital Health Technologies

OI2: Open Innovation 2

IOT: Internet of Things

MAST: Model for Assessment of Telemedicine Applications

ODH: One Digital Health

PbD: Privacy by Design

SME: Subject matter experts

WHO: World Health Organization

WEF: World Economic Forum

Chapter 1: Introduction

1.1 Macro Healthcare Context

In the past two decades, health within Europe has been on upward trajectory. Between 2002 and 2019 alone, life expectancy has increased 4.2 years for men (to 77.6 years) and 3.1 years for women (81.3), a major feat for public health's effective influence on improving lifestyle, education, and quality of care simultaneously (Mortality and Life Expectancy Statistics, 2021). While this progress is encouraging, if we take a closer look, it appears the challenges the health system is facing is increasing. Life expectancy after 65 is 18 and 21 years for men and women respectively, and its estimated only 9 of these will be spent in good health due to the strong prevalence of chronic disease and comorbidities in old age (ibid). Demographics are changing too; lower fertility rates and increased life expectancy are increasing the age of our population (ibid). Those over 65 currently make up around 20% of our population while in 2070 this is projected to sit above 30% (ibid). Poor quality of health in an increasingly ageing population points to a contentious scenario for health stakeholders as these factors will continuously put a strain on health budgets and the dwindling medical staff needed to sustain them (Struckmann et al., 2014; EXPH 2019). Given the previously mentioned macroenvironmental trends, and the recent historical evidence of increased health spending in proportion to GDP across all EU members, this topic will persistently garner attention (Mortality and Life Expectancy Statistics, 2021; Struckmann et al., 2014; EXPH 2019). Increased spending is especially concerning considering that estimates regarding wasted healthcare spending ranges from 10% (OECD, 2017) to 34% (Berwick, D. and A. Hackbarth, 2012) in the USA.

To counter these trends, leading stakeholders in health care are calling for a 'Consumer Centric' shift in health to alleviate burdens placed on the system. 85% of deaths in the EU are due to chronic diseases, many of which are preventable and caused by unhealthy lifestyle habits (Struckmann et al., 2014). Giving patients the knowledge and ability to understand their health will help them better attain life goals, raise quality of life, and as a by product reduce costly reliance on the public healthcare system (de Maeseneer & Boeckxstaens, 2012). The main themes of this shift include a pivot from the current location of treatment, from 'hospital care' to 'home care', and from responsibility of care from 'diagnosis and treatment' to 'prevention and management'(World Economic Forum, 2021 ; WHO, 2016). By introducing home care it is hoped that it will liberate access to healthcare by circumnavigating geographical and time constraints (ibid). By shifting health responsibility toward prevention and management the

hopes are to change and foster healthy lifestyle behaviours and prevent chronic conditions (WHO, 2016). However, these shifts are not easily attainable, they require intensive resources, and need to be implemented without halting the existing, lower value health intervention they are replacing (EXPH, 2019). The European Commission's definition for 'value-based healthcare' going forward has four pillars; personal value (adequate care to achieve patients' personal goals), technical value (achieving best outcomes with available resources), allocative value (equitable distribution among all patient groups), and societal value (positive contribution to social participation and connectedness) (ibid). As we look to realize these goals we introduce digital innovation to our horizon of solutions.

1.2 Wearables

In 2020 global shipment of wearables stood at 444.7 million units, a 28.4 percent increase from the previous year (Statista, 2021). What is drawing consumers toward this technology is the idea of "quantified self" (Swan M., 2009). The notion that by having personalized biometric data (examples being heart rate, sleep and physical activity) users can more precisely understand their health and thus make the necessary behaviour and lifestyle changes to attain their health goals. The issue being that there is scarce tangible evidence of wearables helping users realizing their goals, at fault of a multitude of reasons to be elaborated upon later in the paper.

Wearables at large can measure heart rate, muscle activity, stress levels, physical activity, sleep patterns, social interaction, and even a woman's fertile periods (Piwek et al., 2016). The ability to capture extremely personalized health metrics and leveraging this with other technologies such as big data, interactive technology (ex. Siri and Alexa), and IoT gives wearables the potential to take quality of healthcare to new heights by giving patients more timely, accurate, holistic, and autonomous feedback on their health for which they can use as drivers to change their behaviours ((EXPH 2018; Park, S., & Jayaraman, S. (2003); WEF, 2021.; Patel et al., 2015; Piwek et al., 2016)). The features of greater health attainment mentioned are key contributors to health prevention, management, and goal attainment which industry experts claim to be the future pillars of healthcare (EXPH 2018, WEF 2021, WHO 2016). Another interesting positive contributor which pertains to this technology and health is its widespread adoption by consumers. The extent to which a societies (and organizations) culture is open to change is a vital contributor to the adoption of innovative technologies (Dahlander and Gann 2010) and in 2016 alone it was estimated that 1 in every 6 Americans used wearable technology to some extent (Juniper Research, 2018). Since then, this number has only increased, not only is the prevalence of wearables seen in the American market, but

demand in Europe, and Asia has increased in tandem (Statista, 2021). There are those who would argue this technology is a trend but purchasing patterns and increased health prioritisation (due to Covid-19) support the long-term investment of soft and hard resources into the development and integration of this technology at an institutional level.

Despite the promise of this potentially disruptive technology there lies major pitfalls and gaps in its widespread implementation into the general population. The most prevalent barriers include inadequate patient and physician behaviour and comprehension, attitude, and culture toward health (diagnose and treat vs. prevention and management), equal access and uptake, device inaccuracies, and safety concerns (Ogden and Fixsen, 2014; EXPH 2016). There is also a lack of; data regulation, compelling evidence, policy incentives, procedures, and monitoring (ibid). If a complex system of this magnitude is going to be properly introduced, it will call for a level of sophistication and coordination beyond what is currently standard practice (Kelly, 1995).

Current research is riddled with studies which have been conducted over short term time horizons, and those over longer term horizons are sparse (Piwek et al., 2016). Given that the value of the transformation in question will be determined over a more longitudinal period, this general shortcoming in research is a major pitfall when looking for stakeholder endorsement (EXPH, 2018). Research on a macro level in digital transformation, 'guidelines and principles on digital transformation in the healthcare system', is well documented, especially for the EU. Existing literature consist of frameworks ranging from general ecosystem approaches to more specific technologies regarding DHT technologies exist, but a framework for wearables specifically, is to authors knowledge, non-existent.

1.3 Aim of the Study

It is evident that on the surface, wearable technology has a wide breadth and depth when it comes to biometric monitoring and data compilation. The primary potential benefits for the stakeholders in question include superior profits and new market entry for private companies, reduced health spending for governments, increased quality of care delivered by physicians, and greater attainment of health goals by patients (WHO, 2016; WEF, 2021; EXPH 2016, Bonilla, 2018; EXPH, 2018). Wearable monitoring capabilities can give users real-time feedback on their health progress and inconsistencies. Also, longitudinal data recording and analysis, which could be utilized to identify pertinent cause-and-effect relationships in health and consequently provide individuals and populations with further valuable insight on health prevention and (Brennan et al., 2017). The problem being two-fold, the first being that the current state of wearable technology has clear shortcomings, especially when looking at its

usage patterns and applications in a clinical setting. The second being that it's unclear if roles, parameters, and incentives of the current healthcare ecosystem are conducive for wearable technology development, implementation, and sustained usage. The two primary issues leave us wondering if wearables are in fact a viable solution toward achieving health prevention and maintenance.

As such, the aim of this study is to:

1. Establish the potential value of wearable technology and other resembling functionalities in a primary health care in disease prevention and health management and to
2. Propose a framework to guide the (wise) creation of a value driven innovation ecosystem to stimulate the development, implementation, and sustained adoption of wearable technology

The hope of the framework is for it to be utilized by stakeholders in the industry to remediate its current state of fragmentation and value shortcomings to one of consolidation and evidence backed value delivery (Hwang & Christensen, 2008; EXPH 2018; Patel, 2015).

Chapter 2: Methodology

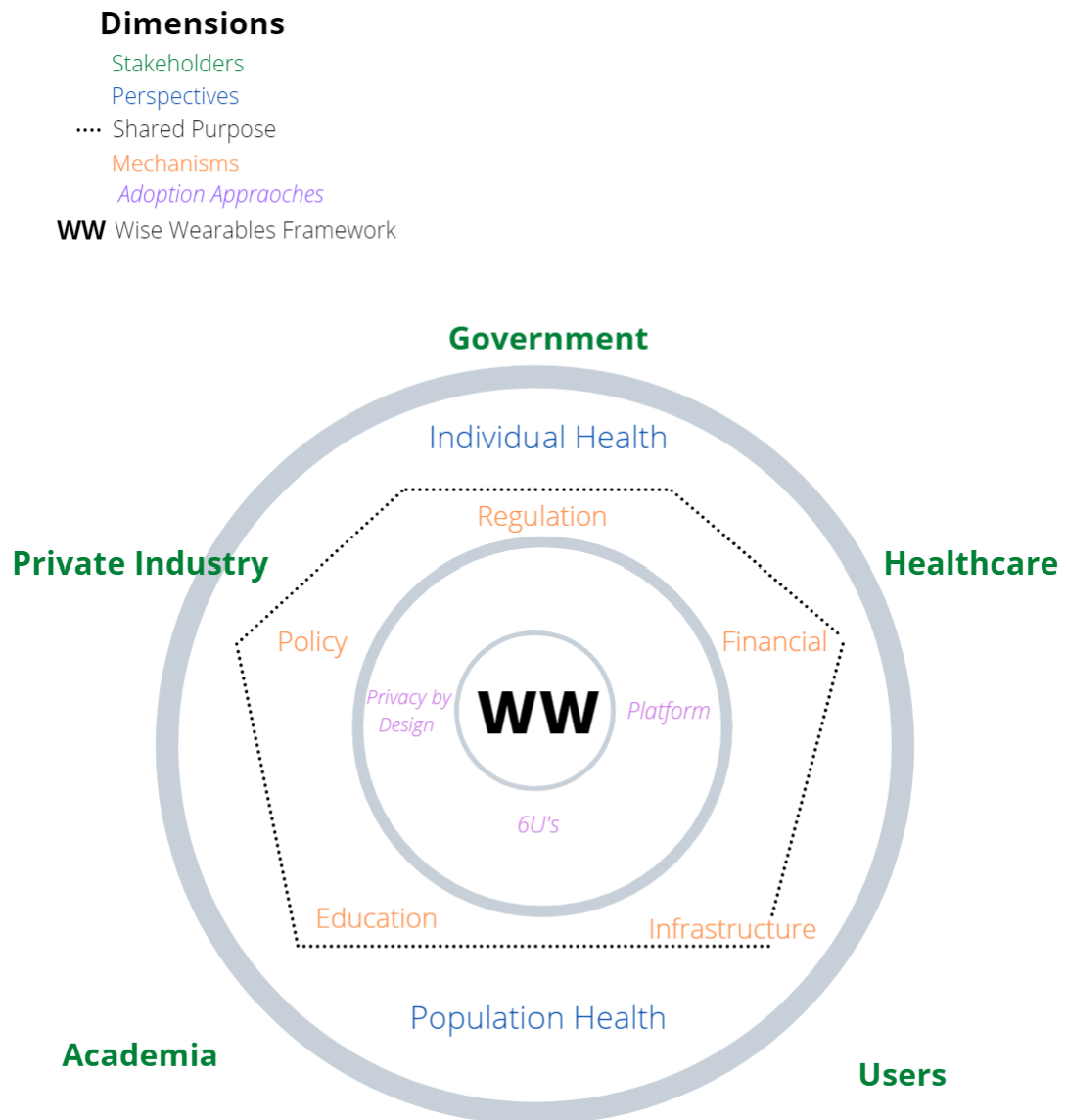
2.1 Overview

To determine if wearables hold potential for healthcare applications, a literature review will be conducted on the future trends and themes in healthcare, and the potential digital solutions hold in catalyzing societies gravitation toward optimal future themes and trends. The literature review will also probe into the difficulties of wearable digital transformation in healthcare, highlighting key opportunities and barriers on a both a systematic (macro) level and on a technological (micro) level. After key opportunities and barriers have been identified, a review of existing frameworks and methodologies for disruptive health technology transformation will be conducted to distil relevant inputs to apply to the first draft of the Wise Wearables framework. Once the first draft of Wise Wearables has been developed it will be qualitatively explored with subject matter experts (SME) from each primary stakeholder group (physicians, academia, health technology developers, and users) to observe both the feasibility of wearables in a real-world application and validity of Wise Wearables as a framework to build innovation ecosystems for wearable development and adoption. For this to be true, Wise Wearables needs to be sound in its efficacy – determining ‘whether the intervention works in principle under ideal conditions’ (WHO, 2016). By building a framework which considers expert research and opinion on both the shortcomings and opportunities of healthcare ecosystems and the state of wearable technology itself, we can harmonize between the two and

ensure Wise Wearables relevancy and practicality (efficacy) in fostering innovation ecosystems which stimulate wearable development and adoption.

2.2 Wise Wearables First Draft

Figure 1: Wise Wearables initial draft



Assumptions made in the Wise Wearables initial draft are the following:

1. Stakeholders: Open Innovation 2.0 is the technique which should be applied to healthcare innovation – this means placing an emphasis on building an ecosystem for stakeholder co-creation and collaboration.
2. Perspectives: There is a demand for wearable enabled individual health attainment and population health management

3. Shared Vision: sustainable alignment can be developed between the stakeholders in question.
4. Mechanisms: Policy, Economics, Infrastructure, Regulation, and Education are instrumental in setting the stage for digital health technology (DHT) development.
5. Adoption Approaches: Privacy by design, 6Us, and platforms are sufficient in tackling the challenge of creating and sustaining user engagement
6. Wise Wearables: The innovation process of wearables needs a framework to guide its development

2.3 Wise Wearables Final Draft Development

The objective of the interviews is to challenge the assumptions made in the initial formulation of Wise Wearables as a framework to stimulate innovation ecosystems for wearable development and adoption. By doing this we can identify any unforeseen barriers that need to be overcome and any opportunities to be seized for each respective stakeholder group. Results of this will be synthesized into the Wise Wearables in a way which maximizes key attributes of efficacy.

The panel from which qualitative feedback will be composed of subject matter experts (SME) from each primary stakeholder group (physicians, academia, health technology developers, and users). Seeing as SME in the field are limited and difficult to reach, the group of individuals that will be questioned will be relatively small. Also considering the complex nature of the subject at hand, exploratory, iterative interviews will be more effective in receiving feedback and insights on existing industry trends.

Feedback and insights gained will be derived from three individuals within each primary stakeholder group. Advantages of the qualitative method is the ability to compare literature findings to real-world contexts, the exploratory style of the interviews allows for agile iteration on further topic development. The disadvantages of the qualitative approach that the conclusions of a limited number of interviewees will be taken as representative of the entire respective stakeholder population, and that the process of finding and recruiting SME to interview is time intensive. Conclusions of interviewees will no doubt be biased on subjective personal experience and perhaps misrepresentative of the actual general opinion. To mitigate any potential bias in one direction, the selection process of the interviewees within each stakeholder subgroup will be done in a manner which ensures the deep level diversity of their professional experience (such as time spent in the industry, education, sector) and opinion. An example being to include a panel of a doctor who practices public medicine, and one who is in

private, another being to interview a start-up in digital health development and a company which is more mature. The idea being that by ensuring a diverse panel, we can retrieve differing opinions on the matter while also identifying commonalities and ultimately distil insights and feedback with both wholistic and basic underlying truths.

Chapter 3: Conceptual Backgrounds

3.1 Digital Disruption

3.1.1 Outlook

A survey in the US of executives, clinical leaders and clinicians in the US was recently conducted and indicated a strong demand for disruptive health technologies (DHT) spanning health systems, electronic health records, and clinical decision support systems (Dafny & Mohta, 2017). It can be expected that DHT's characterized by increased automation, interoperability, and communication via real-time data compilation will result in a few or even all of the following improved health outcomes (EXPH 2016, Bonilla, 2018):

- Create new services and overcomes challenges regarding accessibility to existing or new services
- Lead to cost-effective methodologies that improve access
- Promote person-centred health delivery
- Empower the patient/person
- Disorder old systems
- Create new professional roles and capacities
- Create new sets of values for the health workforce, patients, citizens and community
- Introduce transformative cultural change

More specifically, large data sets that cover populations with diverse demographics and health situations will be vital in uncovering granular cause and effect relationships in health which will in turn enable great breakthroughs in population health management and attainment (Brennan et al., 2017). A few reputable studies have analyzed these types of DHT in practice with compelling success, supporting argumentation toward the continued investment of resources toward these technologies (Cogliano V, 2011; Victora & Barros, 2006; Muller et al., 2016).

3.1.2 Difficulties

The issue with DHTs is that adopting these systems come with complex intricacies both technically and within the stakeholder ecosystem, especially when implementations have

to do with human-human interaction (complex systems) rather than administration (simple systems) (Kelly, 1995).

Table 1: Pros and Cons of Complex Systems	
Benefits	Disadvantages
Adaptable	Nonoptimal
Evolvable	Noncontrollable
Resilient	Nonpredictable
Boundless	Nonunderstandable
Novelty	Nonimmediate

Based on: Kelly (1995)

From procurement, implementation, to monitoring and evaluation difficulties DHTs need to be dealt with prudently to ensure sustainable value delivery to the health ecosystem (Ogden and Fixsen, 2014). The most apparent barriers (of DHT uptake) are: lack of engagement of users; resistance in the openness and culture of the health workforce and organisational/institutional structures; inadequate networks, processes, and coordination; economic and legal factors; lack of political support, and a lack of knowledge and evaluations (EXPH 2016, Ogden and Fixsen, 2014). Once adopted DHTs can also easily increase social and health inequalities (Latulippe et al 2017; Weiss et al., 2018). High variance in factors such as income, education, digital literacy, and access to internet creates a ‘digital divide’ between disadvantaged and higher socioeconomic segments of the population (Weiss et al., 2018). Inequities are contentious issues for DHT uptake because its disadvantaged populations who have the most to gain from up and coming DHTs, while its those of higher socio economic status who are the typically the first to adopt them (ibid). This situation of lopsided adoption where inequalities are further exacerbated is an outcome directly in contrast with public health goals. The intricacies of DHTs and their stakeholders make the concept of “value based healthcare”, hard to achieve. The reality of the difficulties of incorporating DHT in healthcare is reflected in the industries laggardly behaviour in adopting technologies in comparison with others (EXPH 2018). In order to sustainably foster these complex technologies into our current system, current process and methods of DHT development, implementation, evaluation and monitoring need to be challenged (Barnes MR, 2012).

3.2 Open Innovation 2.0

3.2.1 Definition

The current traditional approach toward health and innovation assumes a linear model. X incremental policy change will translate to y incremental result. Open Innovation 2 (OI2) is a new set of principles which focusing on intensive collaboration to deliver technologies with increased efficiency, productivity, predictability, and profitability (M. Curley et B. Salmin, 2018). The objective is not to set policy to drive change, but to establish a co-creation, collaboration ecosystem to drive change.

Dependency > Independency > Interdependency

Traditionally dependencies in a supply chain are exacerbated, if something goes wrong, the entire flow of progress is halted. OI2 aims to create a ecosystem in which innovation takes place autonomously in all phases in development by diversifying the innovation process flow to relevant external actors in close collaboration. By doing this the ecosystem can continually iterate at all phases of development and ensure alignment with technology development (M. Curley et B. Salmin, 2018).

Solo > Cluster > Ecosystem

A single company alone cannot handle the complexity to proliferate a disruptive new technology in an changing environments (Barnes MR, 2012). Knowledge clusters (a constellation of experts on a specific topic) have been mentioned as a solution to expanding innovation capacity, but knowledge beyond that niche can leave development stunted (Dougherty D, Dunne D (2011)). The quadruple helix ecosystems incorporated users, governments, industry (healthcare providers and private sector), and academia in working together to contribute value to a common goal (Carayannis EG, Campbell DFJ 2010). 'By accessing a greater number of knowledge sources, the firm improves the probability of obtaining knowledge that will lead to a valuable outcome' (Leiponen and Helfat, 2011).

This approach toward innovation which expands capacity in multiple domains enables a holistic approach which ultimately heightens the probability and speed of success in the innovation process. With the ability to experiment with end users, especially at early stages of development, innovators can much sooner differentiate between products with potentials and those with pitfalls (OISPG, 2012).

3.2.2 Shared Purpose

For synergies to be proliferated, effort and knowledge must be aligned. This can be done by creating a Shared purpose and defining:

- A Shared Vision: Creating a powerful idea which all actors can work toward
- Shared value: A system from which all actors of the innovation ecosystem can extract their own respective value from - creating win-win situations for all
- Shared values: Creating decision making values for the innovation in question so stakeholders can rely on guidelines when facing uncertain situations
- Stored Values: A repository where data is stored and utilized to help shape solutions.
- Shareholder Value: The contribution of private industry is quantified by the value created for shareholders. If incentives aren't apparent, the quality of inputs and outcomes will reflect this.
- Shared Value at Risk: Considering not only the risk of investments made but, also the risk of non-compliance with regulation can allow innovators to mitigate losses when a competitor's dominant design emerges, and be held accountable for developing responsible products through punitive measures (fines, and regulation).

(Porter ME, Kramer MR (2011); Curley M (2004))

3.2.3 Designing for Adoption

It is estimated roughly 80% of the value of a innovation comes from the adoption it receives rather than the value it creates (OECD, 2010). With that in mind, there are some key attributes a product must be designed with to increase probabilities of adoption.

3.2.3.1 6U's

A digital product has essential aspects (the 6U's) for its adoption over the short and long term (M. Curley et B. Salmin, 2018):

- Utility: The perceived usefulness of the product in question. Without value, there is no incentive to adopt.
- Usability: The ease of use of the technology. A technology may have amazing potential but if there are barriers (other software adoptions, ambiguous customer journey) involved, adoption will be hampered.
- Uniqueness: Providing a product or service which has not been possible before creates strong adoption demand.

- User Experience: the ‘touch and feel’ of a technology as you interact with it, striking the right balance between user experience and utility act favourably on adoption.
- Ubiquity: Technologies that are positioned to exploit network effects (increased value with every additional user) can have strong adoption rates once a certain threshold of users is reached.
- Users: When an innovation is driven by a strong network of lead users, it ensures the technology is solving a problem and/or tackling an opportunity.

3.2.3.2 Platforms

A large component of OI2 is platforms. platforms are mode in which the technology in question serves as the basis for which external innovators can develop their own technologies, services, or product upon (Gawer and Cusumano, 2013). This engagement creates an ecosystem of re-usage and re-configuration which enables economies of scope and scale consequently benefitting the quality and value created by the platform (Meyer MH, Lehnerd AP (1997)). Another plus of potent platforms is that they are highly adaptable to dynamic environments and this ability corresponds to sustained value delivery given optimal inherent incentives (ibid).

3.2.3.3 Privacy by Design

Privacy is major concern for users, especially regarding data pertaining to sensitive issues. Privacy by design (PbD) is a notion that privacy must be an integral part of the innovation process rather than simply complying to legislation and frameworks. The gist of PbD is not about building fortresses of protection but rather designing datasets in a way that they do not need protecting (A. Cavoukian, 2009).

3.2.4 Culture of Openness

The notion of openness and innovation stems from the idea that a single entity cannot innovate in isolation (Dahlander and Gann 2010). The extent to which a societies (and organizations) culture is open to change is a vital contributor to the adoption of innovative technologies (ibid). In innovation cycles that that are typically longer and more complex (like in health care), public institutions have a integral part to play as they need to create an environment which is conducive to innovation as ultimately they are leaders in the procurement process and guiding user-industry-research collaboration to provide the best odds for scale-up (European Commission, 2018; Kalpaka A, Sörvik J, Tasigiorgou A., 2020). Providing public research and infrastructure funding and optimal conditions (regulatory, funding, policy, leader(s)) are the at the epicenter of thriving, capable and dynamic environments (ibid).

3.3 Existing Framework Landscape

3.3.1 MAST, JASEHN, WHO

'Model Frameworks' suggested by the EXPH 2018 include MAST (Model for Assessment of Telemedicine Applications), JASEHN, and the WHO. The MAST framework is commonly used by European decision makers to evaluate and compare potential telemedicine technologies (Torbjornsen et al., 2014; Rasmussen et al., 2015; Vis et al., 2015). The issue with MAST being that it only focuses on the procurement process of potential (telemedicine) technologies (Kidholm, 2012). Guidelines for the development phase are omitted, and those for implementation are limited. Solutions built without beginning to end collaboration with relevant stakeholders are unlikely to see uptake (Patel et al., 2015). The JASEHN framework is one developed by the European Commission which strives to provide guidance on the implementation process of digital technologies by identifying the different phases and stakeholders to be involved in the technology procurement process (Jasehn, 2017). However the Jasehn framework lacks specifics in assigning key objectives to respective stakeholders, leading to questions of accountability and governance in the process. The WHO provides a framework for building a 'claims-based approach' toward developing health technologies to ensure prudent engagement and evidence building for the progression and buy-in of digital products (WHO, 2016). The problem with this framework being that it fails to acknowledge new innovative ways of working. Although the WHO framework places an emphasis on collaboration, there lies lack guidance on how to execute on this.

3.3.2 One Digital Health

One Digital Health (ODH) focuses on three domains (individual health and well being, population and society, and environment) and takes a systematic approach to blending health and life sciences with digital technology (A. Benis, 2021). By infusing the DNA of healthcare and well-being with open innovation and computer and data science methods, ODH provides a health informatics strategy aimed to enhance the spread of digital health in the short, medium, and long term (Lovis C., 2018). In the short term by giving individuals the tools to manage their own health, medium term by allowing communities to examine their population health, and long-term by allowing population health comparisons between different environments (A. Benis, 2021). By focussing on long term health technologies future generations of healthcare stakeholders will be equipped to handle the intricacies of future health scenarios in a digitally fluent world (Nohr C et al, 2016). More specifically ODH strives to provide decision makers with the guidance to 'support, improve, and lead' efficient end-to-end processes for predictive,

personalized, preventive, and participatory health care’ (Alonso SG, 2019). Incorporated in ODH are elements of openness and culture, evident as the importance of education, engagement opportunities, and value to citizens and health professionals is accentuated. As mentioned earlier the value of technology is highly dependent on adoption and engagement and so its important to appreciate the rigorous approach ODH health takes toward users. Regarding data management another important consideration of ODH are the principles of industry 4.0; the automation and connectivity of systems and the objective of FAIRER data (findable, accessible, interoperable, reusable, ethical, and revisable) (Chute C. French T, 2019). By tackling innovation in this universal manner, the healthcare ecosystem can sustainably harness the resources and capabilities to improve the health of individuals and the populations.

3.4 Wearables

3.4.1 Promises

3.4.1.1 Market Outlook

One potential technology that holds great opportunity to disrupt and benefit the health system is wearable technology. Hearables, watches, wristbands, clothing, and other ‘wearable’ products are seeing heavy worldwide adoption (watches and wristbands especially). In 2020 global shipment of wearables stood at 444.7 million units, a 28.4 percent increase from the previous year (Statista, 2022). The leading product of this category was smart watches (primarily the Apple watch) where consumers found the fitness and bio indicators features the most enticing feature of the product (ibid). Given the purchasing speed of wearables its evident the desire for ‘consumer centric healthcare’ (as mentioned earlier) exists and is currently underway. Add the desire for self diagnosis (as seen from ‘internet diagnosis’) and governmental health authorities are likely to find increasing instances of individuals making health decisions based off of unregulated technology – a potentially dangerous and costly scenario (Piwek et al., 2016). Wearable technology has great potential to positively impact public health, but if unchecked for its wider implications it may prove detrimental.

3.4.1.2 Success in Clinical Health

Wearables have the capability to simultaneously monitor multiple bio metrics allowing multifaceted and longitudinal data compilation, both key attributes in data compilation and analysis for individual and population health management and attainment. Medical issues can be monitored, and information can be disseminated to induce positive behaviour change in chronic conditions. Evidence of positive behaviour change by technology already exists for obesity, hypertension, and anxiety (Carter et al., 2013; Christensen et al., 2004; Gazit et al.,

2021). Sleep abnormalities (which are traditionally hard to diagnose) can be identified and improved through heart rate and breathing volume monitoring (Harrington et al., 2013). Depressive symptoms can be diagnosed by monitoring frequency of conversations, amount of activity, and sleep duration (Chen et al., 2014; McCall, 2015). Wearable data could also be used as a “predictive preventative diagnosis tool”, helping users stay proactive in combatting potential diseases and illnesses. Current digital solutions for each respective topic mentioned above exist, but are typically synonymous with high costs, effort expenditure, and ultimately, levels of patient attrition (Rosser et al., 2009). Wearables could provide a more affordable, practical, and effective solution to what currently exists on the market today.

The most promising longitudinal study of wearables in a clinical setting is a mobile hypertension case which included 28 189 participants and spanned over 3 years (Gazit et al., 2021). Participants utilized a wearable to monitor blood pressure where they had a mobile data interface which relayed information and automated coaching so users could better self-manage their high blood pressure. The specific relationship established was that higher physical activity was mediated by automated lifestyle coaching which in turn lowered blood pressure. Interesting to note that the mobile program played a clinically significant role in lowering the blood pressure of less engaged participants as well (ibid). Considering the significance of results, the hypertension study provides encouraging evidence of the positive impact that wearables can have when designed, implemented, monitored, and endorsed adequately.

3.4.2 Barriers

3.4.2.1 Clinical Evidence

Although widely used in a general setting, wearables in a clinical setting at large are lacking the empirical evidence necessary to champion their widespread adoption ((Patel et al., 2015; Piwek et al., 2016)). Common aspects of current literature include individual subjective reports and short time-frames (Patel et al., 2015). Considering the context in question and the sensitivity of different health stakeholders, subjective reporting and short timelines surmount to insufficient scientific evidence and thus lack the lustre to inspire the endorsement necessary for widespread clinical wearable development and application (EXPH, 2018). Going forward more standardized, quantitative, and longitudinal studies need to take place (Piwek et al., 2016).

3.4.2.2 Adoption

The largest segment of the current wearables market comprises of healthy individuals of a higher income looking to quantify their health progress (Patel et al., 2015). For equitable

adoption, wearable technology would need to have characteristics which appeal lower income, unhealthier individuals. Fitness wearables also suffer from a lack of sustained engagement, recent surveys found that around a third of users stop wearing these devices after few months (Hermesen, S., 2017). This statistic is problematic as studies show that sustained behavior changes need time to develop (Lally, P., 2010).

The current reliability and accuracy of these devices is also slightly concerning with error margins greater than what would be clinically acceptable (Lee, 2014; Case, 2015). Inaccuracy is especially concerning if users become over-reliant on their automated technology, if this is the case it may provoke users toward mis-diagnosis or a false sense of security (Krantz 1980; Goyder, 2010). Wearables are also received differently depending on a users personality (Ehrenberg et al., 2008). For example, for the same device, some users could utilize and cope with it seamlessly, while others could find the technology invasive (O’Kane et al., 2008) and under-utilize its functions. In order to achieve health objectives, solutions for all personality types would need to be developed. User interaction with medical wearable technology is a complicated matter and considering the intimacy of the relation between the product and the user, needs to be examined and developed carefully if wearables are going to see safe and sustained adoption.

3.4.2.3 Privacy

One of the most contentious issues regarding the widespread implementation of wearables are concerns over privacy (EXPH 2018; EXPH 2016; Piwek et al., 2016; A. Cavoukian, 2009). Current users of wearables do not own their data, its managed by the manufacturer who sells the device itself and they have been known to sell this data to 3rd party agencies (EXPH 2018). This is concerning for users as the data itself it is also quite revealing, often entailing the age, sex, weight, email, and location (Strava, 2022). Although data is often anonymous there exists sophisticated algorithms to cross reference it with users other digital activity, giving owners of these insights potent information with which to predict an individual’s personality (Lambiotte, 2015) and risk-taking behaviour (Kosinski et al., 2013). Communications between devices such as smartphones are also susceptible to hacking (Kirk, 2014). Scenarios where sensitive health data is sold or stolen undermine efforts made to achieve health system goals. If wearable technology is to be safely implemented, effective processes for evaluation and substantial infrastructure regarding privacy and data usage must be fostered to ensure the integrity of the health system in question.

Chapter 4: Wise Wearables Framework Proposal

4.1 Wise Wearables: Part 1

The following is a description and rationalization for the first draft of the Wise Wearables Framework depicted in figure 2. The goal of this framework is to provide a roadmap to identify who should be involved (stakeholders), what they're striving toward (Individual Health and Well Being, and Population Health), why they need to be involved, and how they need to be organized in the innovation process (Shared Purpose, Mechanism, Adoption Approaches).

4.1.1 Stakeholders

OI2 places a strong emphasis in co-creation and collaboration in the innovation process to develop the most sustainable and value driven technologies possible. As such we start by identifying the key stakeholders involved to include in the initial decision-making process. The rationale for the stakeholders involved is the quadruple helix model proposed by Carayannis EG and Campbell DFJ 2010. It is to be noted that the fourth pillar of 'industry' was decided to be broken into both private industry and health care as they have differing risks and rewards in the DHT innovation process.

4.1.2 Perspectives

4.1.2.1 Individual Health and Well Being

As mentioned previously one of the main shifts for health culture will be away from diagnose and treatment toward prevention and maintenance (World Economic Forum, 2021; WHO, 2016). What this means specifically for users of wearables is that the technology must give them the tools and feedback necessary to change their behaviours in order to obtain their unique health lifestyle goals. By doing this society can prevent chronic conditions, alleviate burdens on the public healthcare system, and create a healthier happier population.

4.1.2.2 Population Health

A benefit of monitoring data trends across large diverse populations is that it gives the ability to better establish the cause-and-effect relationships of health outcomes and thus give health practitioners and educators the information needed to give health advice to populations to better avoid unhealthy outcomes and obtain healthy ones (Brennan et al., 2017. Benis A et al. 2021). This feat is a pivotal contributor to helping society reach a health culture of disease prevention and health management.

4.1.3 Shared Purpose

Before making decisions it's important that stakeholders first come to a shared purpose. Although perhaps painstaking and difficult in the short-term, establishing a firm common ground where values, principles, risk sharing, and information can be leaned upon to guide the decision-making process will ensure the alignment of the technology to all its stakeholders in the long run (M. Curley et B. Salmin, 2018). This alignment between stakeholders and product is essential for the development and endorsement process of technologies which will ultimately prove vital for sustainable DHT adoption.

4.1.4 Mechanisms

To create an ecosystem that's well functioning for DHT adoption, resources and capabilities need to be developed over different mechanisms to ensure the adoption and longevity of DHTs:

- **Education:** Education is the pillar which will be used to transform the culture of individuals, organizations, and society in the new approach to healthcare. By developing an education strategy that enables transparency, useful information, and a two-sided dialogue, culture toward wearable preventative care can start to be fostered among society (Dahlander and Gann 2010).
- **Finance:** By offering an economic environment that's lucrative enough to attract the time and resources of different sizes and expertise's of firms, the natural laws of competition for a superior product/service may take place. This may include upfront subsidies for developers and compensation packages for those who 'lose' to a competitor's dominant design (European Commission, 2018; EXPH 2018). Another important consideration is to re-examine the reimbursement schemes for which the medical industry is currently compensated as its founded upon diagnosis and treatment and relatively incompatible with a shift to prevention and maintenance (EXPH 2018).
- **Regulation:** By providing effective guidelines, punitive measures, monitoring, and evaluation techniques the integrity of developed products can be kept intact (Ogden and Fixsen, 2014; EXPH 2016). The idea is to create an innovation culture where innovators are motivated in going above and beyond requirements and set new standards, rather than submitting to the bare minimum (Porter ME, Kramer MR, 2011; Curley M, 2004).
- **Infrastructure:** Providing the physical and digital infrastructure necessary for co-creation and collaboration are to take place necessary to stimulate innovation. An

ecosystem that is sparse in resources and connectivity cannot be expected to thrive (Kalpaka A, Sörvik J, Tasigiorgou A., 2020).

- Policy: Political bodies can send a strong message to stakeholders and ecosystems by implementing higher level public policy which indicates vision of future healthcare. By implementing persuasive policy governments can in turn garner the attention and resources necessary to kickstart and catalyze the development process of the vision in question (European Commission, 2018; EXPH 2018)..

4.1.5 Adoption Approaches

4.1.5.1 Privacy by Design

Considering the sensitive nature of health data, privacy is a point of concern for many stakeholders in the ecosystem (EXPH 2018; EXPH 2016; Piwek et al., 2016). To gain the confidence of users, DHTs need to be developed with PbD principles to ensure identity anonymity. A key potential benefit of the data from wearable technology is its interoperability - the ability for wearable data to be dispersed to different specialists and functional groups as needed for analysis and feedback to users (Chute C. French T, 2019). Therefore, a careful balance between privacy and interoperability must be struck.

4.1.5.2 Platform

Two strong points of difficulty over the current state and concerns over wearables are how this technology can be utilized by everyone equitably despite nuances in health goals, socioeconomic status, and personality (Latulippe et al 2017; Weiss et al., 2018; Ehrenberg et al., 2008). Considering this, the ideal solution cannot have a one size fits all approach to users and a potential solution to this is to take a platform approach. By creating a platform solution, a large portion of the innovation process is naturally outsourced to external innovators where the potential value of the technology can be proliferated by offering quality solutions which resonate with a wide array of users (Gawer and Cusumano, 2013). Without platform technology it is simply not possible to expect one company to have the innovation capacity to develop value-add aspects to all corners of society (Dahlander and Gann 2010; Leiponen and Helfat, 2011).

4.1.5.3 6U

By following the principles of the 6U's (Utility, Users, User Experience, Usability, Uniqueness, and Ubiquity), the predictability and confidence of the adoption potential of wearable technology can be drastically increased over the long term (M. Curley et B. Salmin, 2018). This focus on adoption has high pertinence as wearables currently see high attrition rates

in timelines under a year (Hermesen, S., 2017, Rosser 2009). If an investment of resources is made to cause the magnitude of health shift desired, the wearable solution is one that would have to become a regular, everyday part of life for users. A goal that cannot be achieved without giving a painstaking eye to all aspects of the product in question.

4.2 Wise Wearables: Part 2

Figure 3 depicts the final draft of the Wise Wearables model done after qualitative interview validation. Interviewees were mainly from Canada and Europe and had an age range between 22 and 73; 5 women were interviewed and 7 men; backgrounds spanned students, retirees, business professionals, surgeons, health tech business professionals, healthcare charity professionals, and healthcare in academia. The idea was to interview a wholistic panel on the subject by incorporating feedback from healthcare users, service providers, private industry, and academia to better determine the attitudes and nuances between and among these groups to validate:

- The perceived value and potential of wearables and other functionalities in the healthcare system
- The practicality of the Wise Wearables framework in question

4.2 Results

The following list can be used as reference for the assumptions in the Wise Wearables framework that were tested. Answers relevant to the framework assumption are marked with the corresponding number.

1. Stakeholders: Open Innovation 2.0 is the technique which should be applied to healthcare innovation – this means an emphasis on building an ecosystem for stakeholder co-creation and collaboration.
2. Perspectives: There is a demand for wearable enabled individual health attainment and population health management
3. Shared Vision: sustainable alignment can be developed between the stakeholders in question.
4. Mechanisms: Policy, Economics, Infrastructure, Regulation, and Education are instrumental in setting the stage for DHT development.
5. Adoption Approaches: Privacy by design, 6Us, and platforms are sufficient and holistic in tackling the challenge of sustained engagement
6. Wise Wearables: The innovation process of wearables needs a framework to guide its development

Regarding the DHT in question, who are the main stakeholders who should be involved work with (1)? How engaged should they be? What do you think works, what doesn't? what would you like to see?

There was consensus among respondents about the stakeholders to be involved in the wearable's development process (1). It wasn't obvious for users and select business respondents to intuitively include academia, but when asked if they would feel more comfortable with their involvement in the process they said yes (1). Heavy involvement and endorsement by doctors were said to be needed, especially on product development, validation, and the education of patients (1). It was also agreed that the bulk of innovative capacity would come from the private industry (1). Government was wanted for standardization and regulation of the wearable system (1).

Do you think we're utilizing technology available properly for individual and population health (2)? Why or why not?

All interviewees agreed at large that there is room for incorporating digital into individual and population health and that we we're under utilizing the current capabilities of different technologies (2). The stigma toward healthcare and technology is that the industry is a late adopter of technology (2). Few respondents mentioned that the current landscape of digital in health is lop-sided with champions and laggards present on both a practitioner and regional basis. SMEs in business highlighted that the motivation to use digital technologies highly increased because of covid and evidence of this is apparent by increased venture capital investment in these technologies (2).

Given the innovation in question do you see it as a feasible value-add for individual and population healthcare (2)? Under what conditions could it flourish(3,4,5)?

The notion of utilizing wearable technology to measure biometrics and influence behaviour changes toward making proactive measures in individual and population health was looked upon favorably as a healthcare solution by all respondents (2). Respondents report that conditions for success are hard to reach. Private industry interviewees argue the healthcare system and regulatory framework needs re-engineering or would need to be navigated with extreme prudence if a DHT of this magnitude was going to work within the existing system (3, 4). Health and Business experts also mentioned the dominant design of wearables unlikely

resembles anything that exists right now (5), and that economic incentives need to be there for everyone (cheap for users, making/saving money for everyone else) or else uptake won't happen (3, 4). Users want proper endorsement by healthcare professionals (3, 4, 5), privacy data controls (5), and standardization (5). All in all, there was a consensus that this process would be extremely disruptive and would need intensive action on stakeholder alignment (3,4).

Specifically, where do you see the government's role in setting an environment for innovation in digital health care (4)? Do they have the current resources and capabilities to do so?

In general respondents supported the notion that government should be involved in the regulation, policy, and financing of initiatives but they did not have confidence in the government to execute and expected them to be laggards in the innovation process (4). Users wanted government to be at the helm of the technology's standardization and regulation (4, 5). Business, healthcare, and academic SMEs aired that government should be more involved in financing by not only improving the amount of access to capital but reducing frictions in the process to obtain it (4). Government involvement on assisting or leading an initiative to build infrastructure for a DHT innovation ecosystem was not mentioned (4). This is not surprising as this is not standard practice, although innovation centres do exist. When the idea of government funded infrastructure (constellation of 'innovation labs' to exploit clusters of knowledge over different geographical areas to catalyze the development process) was introduced to business, academic and healthcare SME it was looked upon favourably (4).

Do you feel the current ecosystem for innovation in health is sufficiently equipped to develop a project like wearables (policy, financial support, infrastructure, regulatory, education (4))?

Respondents felt that each entity on their own has unique skills required for development but there was general agreement that the motivation and way of organizing these different actors to come together and collaborate was not there (4). Adding that some jurisdictions and practitioners have more hunger for digital disruption than others. A few reputable SMEs said that the desire to change that status quo of health would come from the people; that a widespread wearables scenario would come from consumers desiring products from private companies and that only when adoption becomes so vast will government react for financial, regulatory, or policy reasons.

What are the challenges for you (in general) of fostering out an old health intervention and adopting a new one like this? Start small then go big.

Cultural and educational shift for doctors and users on the way they perceive health and changing their behaviour is the biggest barrier (4, 5). Providing something disruptive enough (getting people to care) to incentivize change but incremental enough for seamless adoption (getting them to use it) (5). Business and Healthcare respondents outlined the challenge of offering something that makes people money which at the same time is not inexpensive for users and the healthcare system (3, 4). Respondents also mentioned capacity issues in both getting doctors feedback on the product while also training them to use and communicate the product to patients effectively and safely. Main themes that were mentioned by respondents were shifting culture, aligning incentives, and ensuring simplicity of use (3, 4, 5).

How do you see the trade-off of data privacy and interoperability for value delivery regarding this technology? Do you anticipate any solutions?

As literature would suggest respondents indicated privacy as an issue. Clearly describing what data is, why it is being collected, and how the data will be used in an easily digestible manner were the focal points of concern (5). Many user respondents mentioned that giving users the autonomy to choose who they want to share their data would be beneficial. Some SMEs argued the practice of protecting data is not a major issue, regulations are already in place and enforced by regulation but increased awareness and others argued that critical thinking over security is immature and needs to continued and increased attention (5). A worthy topic of concern brought up by a few respondents in all stakeholder groups is providing users privacy from their own data - how to have constant data recording without being invasive (5)?

Is it important to use academic knowledge or frameworks when developing or monitoring innovations? Why or why not?

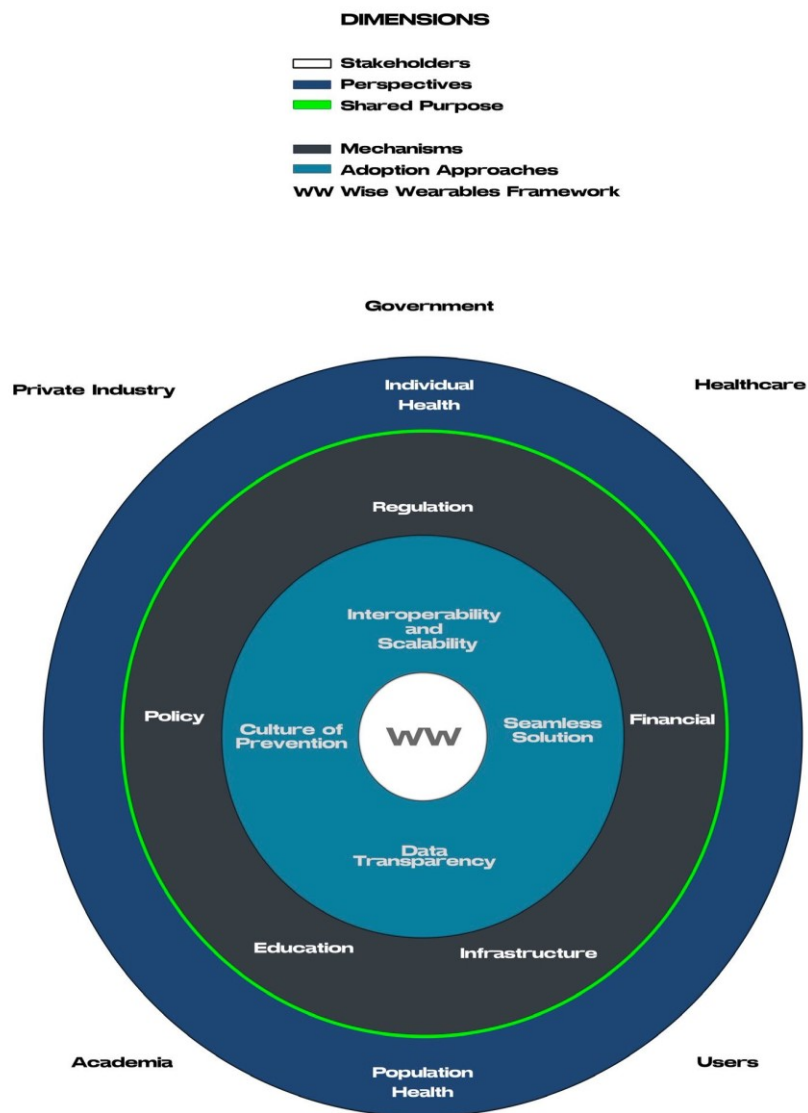
Overwhelming consensus of 'yes'. The arguments of support were that an academic backed framework provides the stewardship of being an objective source of review, analysis and recommendation. An extremely valuable tool to be used in guiding and orchestrating a complex and resource intensive innovation process.

4.3 Wise Wearable's Final Proposal

Figure 2 depicts the Final Proposal of the Wise Wearables Framework. The conveyance of Adoption Approaches in the framework changed as a result of the interview process. The Platform, Privacy by Design, and 6Us approaches initially depicted were too theoretical and

counter-intuitive when the framework was attempted to be understood by respondents. Instead, key barriers of adoption identified in both interviews and literature review were chosen to be reflected instead, to highlight more tangible goals to achieve in coaxing the adoption process. An extrapolation on the rationale behind the framework amendment and its remains will be conducted in the general discussion.

Figure 2: Wise Wearables final framework



Chapter 5: Discussion – Wise Wearable Framework Analysis and Value

5.1 Who: Stakeholders

5.1.2 Private Industry

Leading the way in the DHT revolution will be private industry due to the degree of sophistication in their resources and capabilities. For the DHT in question, public enterprises do not have the expertise or capacity required to successfully deliver on a DHT of such magnitude. On their own private firms do not have the resources or capabilities to pull off a technological ecosystem or cultural shift like the wearable health initiative begs for either. If technology is going to proliferate preventative healthcare, it will require the collaboration of firms across knowledge specializations who are orchestrated in a communicative, purposeful, and fluid manner.

5.1.3 Healthcare

By incorporating the objective eyes of healthcare and academia in the development process, private companies can increase the likelihood of adoption. Developing a product which is trusted and utilized by healthcare professionals is a major contributing factor for adoption. By incorporating the feedback of medical professional's, private companies can ensure the value delivery of their product on both the bottom line of health but also as an instrument to be integrated regularly in the medical profession. The population at large has an increased appetite to incorporate digital in health and if the technology in question is championed by their doctor, they are much more likely to adopt.

5.1.4 Academia

Academia is an essential to include in the innovation process as they act as a trusted objective facilitator between stakeholders. Academia has the knowledge capabilities to be on the forefront of cutting-edge ideas and methodologies which businesses can then utilize in their development process. They also have the research capabilities necessary to build quality evidence to influence the buy-in of governments and health care in the universal efficacy and impact of products. Without academia in the innovation process businesses will find themselves with blind spots in their innovation process and will have a lack of credibility when pursuing key stakeholder endorsement and adoption.

5.1.5 Users

Health products and services are driven by the demand of consumers. If stakeholders build a product or service which solves problem for users (healthcare professionals and

patients) and receives widespread adoption, everyone wins. As such it is essential to have a pulse on the attitudes and behaviours of users in product development. By doing this, stakeholders can increase the probability that the technology which they are building is valued and fit for sustainable adoption by users.

5.1.6 Government

Government involvement in the innovation process varies depending on the jurisdiction. In an ideal setting, healthcare transformation has multiple leaders with government among them championing progressive policy, regulation, and financial incentives to stimulate the initiation of the ecosystem required to innovate for DHT. Governments (depending on jurisdiction) can be sluggish and reactionary when it comes to healthcare intervention. In the case that private industry manages to foster widespread of adoption without institutional backing, governments will play the reactionary role of regulation and standardization to try and provide a degree of equity to access, usage, and safety of healthcare. This scenario is unfavourable as an exclusively private industry driven adoption will likely exacerbate health inequalities between those of a higher and lower sociodemographic. It also puts government in an inexperienced, flat-footed position to try and comprehend the digital health landscape and level the playing for their populations. Evidence of this can be seen with the inequalities private companies have created with social media and the haphazardly reactionary effort by governments to safeguard citizens.

5.2 Why: Perspectives on Individual & Population Health

By helping empower individuals with the information and tools necessary to change their individual health behaviours individuals can prevent chronic conditions and achieve health lifestyle goals. Giving individuals health autonomy is of extreme importance considering the existing trend of an ageing society and unhealthy years spent in old age. Dealing with chronic conditions demands a high expenditure of resources from the healthcare system and by preventing them we can reduce dependency and stress (cost) on the system and mobilize valuable resources to other pertinent health objectives.

Organization and tools for managing population health are underdeveloped in most of the world, this reality was highlighted by the covid-19 pandemic. The importance of monitoring health and delivering accurate and timely information to populations is paramount. By identifying the larger environmental cause and effect relationships of health we have the

information with which we can proactively increase the wellbeing of society and reduce the hardships caused by negative health outcomes.

5.3 How: Shared Purpose, Mechanisms, and Adoption Approaches

5.3.1 Shared Purpose

Developing a shared purpose is the most difficult part of the Wise Wearables process but also the most crucial. Alignment and transparency among the risks, rewards, and information of all key stakeholders is essential in the wearable development process. Without a shared purpose, large scale initiatives have little chance of coming to fruition. The existing system of healthcare compensates hospitals and doctors based on the number of patients they treat. This reimbursement program is in direct contrast to the values of disease prevention and health promotion, more frequent visitors with more intensive ailments for treatment means more money. Doctors and hospitals cannot be currently convinced to adopt a preventative and maintenance health culture as it threatens their financial well-being. If healthcare is expected to get on board with overarching health objectives, intuitive financial incentives for the healthcare system must be established. This can be done by redefining or systematically altering the reimbursement schemes for healthcare professionals, something that is admittedly easier said than done.

Another major difficulty of establishing a shared purpose is getting larger, established vendors to cooperate with start-ups. According to interviewed SMEs the current healthcare business environment is quite hostile, and collaboration between small and large firms are virtually non-existent leaving disruptive innovation in the field at a bit of standstill. Implementing policy to democratize competition and to incentivise collaboration among firms would be a major win for innovation.

5.3.2 Mechanisms

5.3.2.1 Regulation

Creating potent regulation which coerces stakeholders toward meeting standards which protects societies interests can not only protect but also entice investment and innovation toward meeting and even exceeding standards, especially when it comes to public institutions. Governments should be careful so as not to implement regulation which de-incentivises private industry cooperation.

5.3.2.2 Finance

By providing a financial landscape where everyone stands to gain, the natural forces of development and subsequent adoption can take place. An adequate financial landscape

translates to providing the reimbursement and subsidy schemes necessary for all members of the ecosystem.

5.3.2.3 Infrastructure

The innovation process of DHTs is intensive and demands deeper communication and iteration across different disciplines to succeed. As such it requires its own physical infrastructure to reduce redundancies, and to proliferate information sharing, experimentation, and iteration. A formal constellation of innovation labs across geographic areas where domains of differentiated health expertise could be exploited could enable both the specialization of information and organization required to develop DHTs.

5.3.2.3 Education

If a culture shift from diagnoses and treatment to prevention and management is going to take place, ample channels for education need to be established to convince society on why and how this shift will take place. This needs to take place on both a patient level – convincing society why they need to take increased ownership over their health, what data will be compiled of them, and how they are supposed to interact with this new system. And on medical professional level – providing information on why this medical shift needs to take place, and training on how they are supposed to operate with this new technology. Without the knowledge and powerful narratives around the ‘why and how’ of a DHT, the culture change necessary for adoption cannot be achieved.

5.3.2.4 Policy

Policy is at the root of most of the possible utilizations of the mechanisms featured above. By implementing policy which provides clear structure and incentives to DHT innovation, buy-in by external stakeholders is dramatically increased. External leadership is essential as it decentralizes the ownership of initiatives to other stakeholders and thus reduces the burden placed on a single entity to pioneer an innovation. Dispersing responsibility increases the speed and quality at which technologies are developed.

5.3.3 Adoption Approaches

5.3.3.1 Scalability and Interoperability

If wearables are to see widespread adoption, the technology needs to be scalable and interoperable (focussing on 6Us utility, ubiquity, and uniqueness). What this means for private innovators is that the technology must be open source. Open-source systems allow for systems like ‘Platform’ innovation to take place which decentralize the software development process which subsequently increase the quality and capabilities of DHTs. For patients this means a

wider array of solutions will be available to them which suit their highly personalized needs and preferences regarding health management and attainment. What interoperability and scalability means for healthcare systems is that the technology itself can be easily applied across multiple institutional operations, and that information is fluid between healthcare professionals, institutions, and patients themselves. Making scalability and interoperability a reality can drastically increase the quality of care received by patients and improve the efficiency of operations in healthcare.

5.3.3.2 Data transparency

A vital concern in the conversation of wearables revolves around the aspects of usage and privacy in data. If data owners hope to gain the trust of stakeholders and ultimately adopters, they will have to prudently design how they collect data for safe storage (perhaps by using the theory of Privacy by Design) and transparently communicate why exactly they are collecting data, what it is going to be used for, and who it is going to be shared with. Giving users the autonomy of who they share their data with should also be a consideration. Although not all users are vehemently concerned with data privacy, many high-level stakeholders and segments of the general population are and would need to be convinced of a technologies privacy and safety before endorsing and subsequently facilitating mass-adoption.

5.3.3.3 Culture of Prevention

All mechanisms mentioned previously need to be geared toward changing the attitudes and behaviours of society towards health. ‘Getting people to care’ is arguably the largest barrier in the adoption process. If this is not achieved there is no urgency or desire to adopt wearable technology and improvements in individual and population health will remain stagnant. Its unlikely to mobilize all demographics of the population toward health prevention and management, choosing a target group (6Us lead users) in the 40–55-year-old age group is the most relevant and has the highest likelihood of success. The 40–55-year-old segment of the population is conscious enough to know the susceptibilities of ageing and health, but young enough to adopt a healthy lifestyle and effectively reduce the likelihood and severity of chronic conditions.

5.3.3.4 Seamless Solutions

Technology solutions which maximize ease of use are of the utmost importance, this is highlighted by the 6Us ‘user experience’ and ‘usability’. The main feedback when it came to usage from interviewees was that the technology could not be invasive or require effort to upkeep. This feedback is inline with the literature review findings on wearables and user

attrition. One interviewee, the IT Director at the Red Cross hospital in Lisbon mentioned one of the main sources of doctor fatigue comes from user interface engagement. If a DHT solution like wearables is going to be proposed, it must require next to no effort input from patients and must lighten the screen time of doctors in their existing administrative operations. Naturally this raises the notion of incorporating the IOT (internet of things), big data, and artificial intelligence in DHT solutions. Another aspect of seamless solutions is the physical appeal of the technology which relates more to users. Consumers cannot be bothered to adopt an article or accessory they do not find it attractive. The aesthetics of a wearable solution must be inline with aesthetic standards and preferences of all different types of users, whatever they may be.

5.4 What: Wise Wearables

As a result of macroenvironmental factors a strong digital appetite for digital health solutions has emerged. Wearable technology and other functionalities have the potential to enable individuals and populations to reach a greater standard of health. The dominant design of such a technology has not surfaced yet, but the notion of the technology and its application hold potential value for society. If healthcare ecosystems are first aligned their innovation potential can be exploited to their fullest extent. Wise Wearables provides a strategic roadmap toward building innovation ecosystems to stimulate the development and sustainable adoption of DHT.

Chapter 6: Limitations & Future Work

One of the main limitations of the framework is that it is not region specific, especially when it comes to the nature of governance in a respective jurisdiction the gameplan for DHT technology development change dramatically. It also must be noted that no government health officials were interviewed over this matter, so one key stakeholder perspective is adjacent. If they were present, the ability of the government to amend certain policies and systems could be better probed. The framework also calls for major upheaval and reshuffling of the healthcare incentive system, that is a call for a major disruption, and it is fair to question the feasibility of such an objective. It is also important to note that the capacity of healthcare to innovate is limited because of time and resource constraints. Introducing a new method of patient engagement is likely a long and painstaking process. The theme of a long and difficult process continues in changing user behaviour, shifting culture has no specific road map and achieving this involves incredible effort and time to achieve and ultimately has no guarantees. The combined resources and effort to a project like wearables demands monumental commitment from all major players in the health ecosystem. Commitment that will take deep and meticulous

collaboration to foster. If the pandemic showed us anything its that when motivated properly stakeholders can be united toward a common cause. DHT goals of embracing individual and population health are the beacons of health future and we must get there somehow, perhaps Wise Wearables is a good place to start.

Before investing in a DHT like wearables some other studies need to take place to better determine the feasibility of such a project. One theme revolves launching a study to determine what financial incentives will be sufficient for a given jurisdiction and all their stakeholders (users, government, public healthcare, and private industry) and if they will be feasible to implement. Financial incentives at large is one of the most obtrusive barriers. Unless a solution is proposed and inconsistencies rectified, innovation toward healthcare management and disease prevention will not take place. In tandem research on the intricacies and opportunities of shifting health culture would be beneficial. If demand from the population is great enough, markets and governments will respond. Figuring out a way to mobilize society toward prevention and maintenance is an essential first piece of the puzzle. Solving both the financial difficulties and the cultural barriers respectively liberate both the supply and demand side of the wearable DHT equation.

Chapter 7: Conclusion and Recommendations

Wearables other functionalities hold potential for disease prevention and health promotion. For widespread DHT adoption, users (healthcare professionals and society) need privacy assurance, data transparency, simple solutions (technologies which make their lives easier), and a strong culture of prevention and maintenance to conform to. By aligning key stakeholders from the get-go, propitious political, financial, infrastructure, educational and regulatory initiatives can start to be developed to stimulate the production of DHTs. Conducive policy amendments to the current ecosystem encompass; healthcare reimbursement schemes which focus on prevention and maintenance; incentives for organizations to cooperate and collaborate rather than to differentiate; and standardization and regulation toward the equitable uptake of health prevention and maintenance measures. What has yet to be determined within this model is the difference between jurisdictions on the degree of stakeholder alignment and policy amendment needed to achieve ideal innovation ecosystems. Recommendation would be to apply this model to a given jurisdiction and to record the opportunity/barriers (learnings) in achieving a shared purpose, utilizing mechanisms, and adoption approaches. The learnings could then be synthesized into a framework which pertains exactly to the jurisdiction and others

like it which in turn would speed up innovation ecosystem building in healthcare by having a model which is both more replicable and effaceable.

When it pertains specifically to infrastructure for development, a formal constellation of innovation labs across geographic areas where domains of differentiated health expertise could be exploited could enable both the specialization of information and organization required to develop DHTs. It is also recommended that 40–55-year-old age group is chosen as the initial target group for health prevention and maintenance. The 40–55-year-old segment of the population is conscious enough to know the susceptibilities of ageing and health, but young enough to adopt healthy lifestyle habits and effectively reduce the likelihood and severity of chronic conditions. A financial policy incentive recommendation for private innovators would be to implement a profit-sharing scheme for the ecosystem so even those who ‘lose’ to a competitor’s dominant design do not suffer such a harsh financial backlash from their invested time and resources. Regarding privacy, data owners need to communicate with users why exactly they are collecting data, what it is going to be used for, and provide autonomy over who it is going to be shared with.

Originally the Wise Wearables framework was meant to be interpreted as a roadmap toward building a successful healthcare innovation ecosystem for wearable technology. But upon its development and interviewee feedback it is evident the Wise Wearable’s principles go beyond just wearable technology and can be applied to most DHT contexts. The success of DHT inception and implementation is gauged by the strength of leadership among key stakeholders - stronger motivation spread among more key stakeholders will lead to faster results of higher quality. By finding key factors of intrinsic motivation among each actor and harmonizing them toward a common goal, DHTs can be introduced, without this orchestration DHT progress will continue to stagnate. By focussing specifically on open innovation (stakeholders), incentive alignment (shared purpose), instruments to execute (mechanisms), and key objectives (perspectives and adoption approaches), DHTs can produce profit, performance, and prosperity with increased probability and predictability.

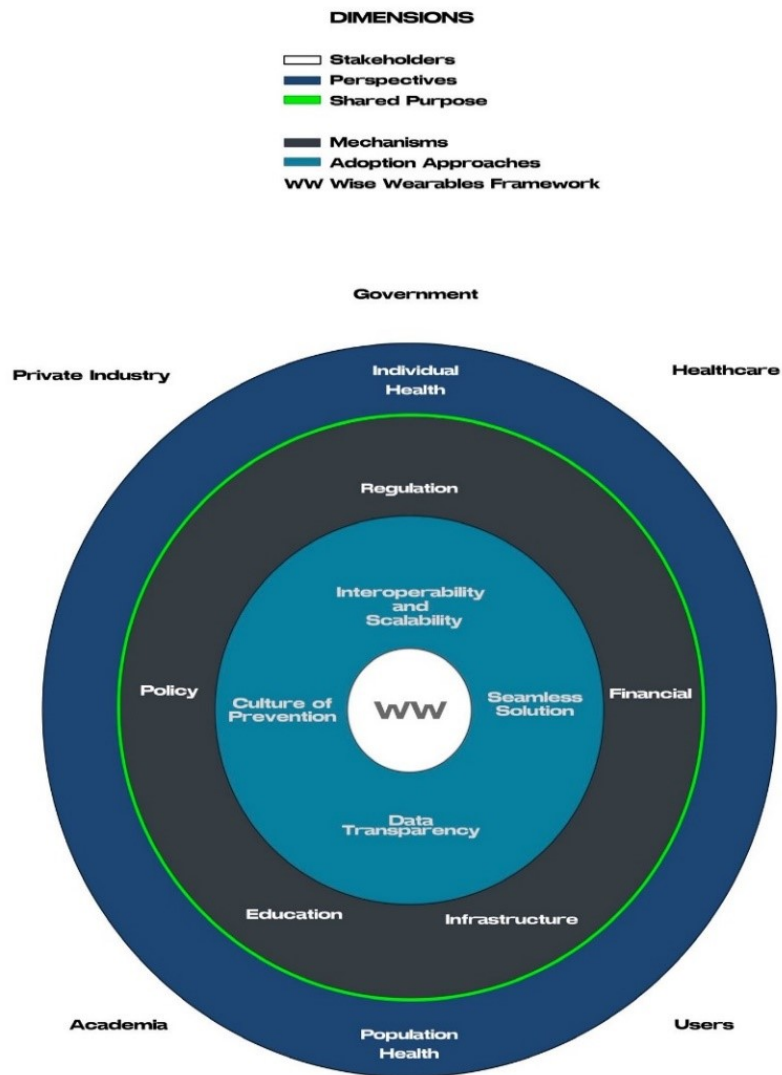


Figure 2: Wise Wearables final framework

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