

Hurdles to Developing and Scaling Remote Patients' Health Management Tools & Systems: A Scoping Review

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Abstract

Background: Despite all the excitement and hype generated regarding the expected transformative impact of digital technology on the healthcare industry, traditional healthcare systems around world have largely remained unchanged and resultant improvements in developed countries are slower than anticipated. One area which was expected to significantly improve the quality of and access to primary healthcare services in particular, is *remote patient monitoring and management*. Based on a combination of rapid advances in body sensors and information and communication technologies (ICT), it was hoped that *remote patient management tools and systems* (RPMTSs) would significantly reduce the care burden on traditional healthcare systems as well as health related costs. However, the uptake or adoption of above systems has been extremely slow and their roll out has not yet properly taken off especially in developing countries where they ought to have made the greatest positive impact.

Aim: The aim of the study was to assess whether or not *recent*, relevant literature would support the development of in-community, design, deployment and implementation framework based on three factors thought to be important drivers and levers of RPMTS's *adoption* and *scalability*.

Methods: A rapid, scoping review conducted on relevant articles obtained from PubMed, MEDLINE, PMC and Cochrane databases and grey literature on google and published between 2012 and May 2020, by combining a number of relevant search terms and phrases.

Results: Most RPMTSs are targeted at and focused on a single disease, do not extensively involve patients and clinicians in their early planning and design phases, are not designed to best serve a *specific* catchment area and are mainly directed at post-hospital, diseases management settings. This may be leading to a situation where patients, potential patients and clinicians simply do not make use of these tools, leading to low *adoption* and *scalability* thereof.

Conclusion: The development of a user-centered, context dependent, customizable design and deployment framework could potentially increase the *adoption* and *scalability* of RPMTSs, if such framework addressed a combination of diseases, prevalent in a given specific catchment area, especially in developing countries with limited financial resources.

Introduction And Problem Statement

The Seventy-first World Health Assembly recognized "the potential of digital technologies to advance the Sustainable Development Goals (SDGs), and in particular to support health systems in all countries in health promotion and disease prevention, and by improving the accessibility, quality and affordability of health services" [1, p. 1]. Among eleven recommendations made to its members, were the integration of digital technologies into existing health systems; scale-up; re-use and adaptation of existing digital health as well as other relevant tools; identifying priority areas; gaps in research and to support implementation.

One area which was expected to significantly improve the quality of and access to primary healthcare services in particular, is 'remote patient monitoring and management'. Based on a combination of rapid advances in body sensors, artificial intelligence and ICT, it was hoped that Remote Patient Management Tools and Systems

(RPMTSSs) would significantly reduce the care burden on traditional healthcare systems as well as health related costs. However, the uptake or adoption of above systems has remained extremely slow and as a result, the roll out of these systems has not yet taken off especially, in developing countries where they ought to have made the greatest impact [2], [3]. Researchers have identified a number of factors broadly affecting the adoption and scalability of digital health systems [4], [5], [26]. These prominently include ease of use, cost-effectiveness, functional efficacy and versatility as well as integration into existing clinical workflows. To the knowledge of the researchers, there has been so far no comprehensive, integrated framework to help guide practitioners in their efforts to design and deploy scalable RPMTSSs with the greatest potential for adoption and scaling [6], [7]. This review assesses the potential of such an integrated framework, especially in developing countries.

On the one hand, RPMTSSs' evaluation studies remain thin on the ground. There does not exist enough consistent empirical, compelling evidence to prove that, or evaluate if, the use of above systems and tools necessarily leads to reduced healthcare costs, better quality of care or health outcomes and -/ or broader, more equitable access to healthcare services [8] [9], [10], [11], [12].

On the other hand, a research gap remains in terms of the contextual issues of such systems. Context-specific infrastructural and socio-economic factors affecting the adoption and scalability of above RPMTSSs do not seem to receive adequate attention during the planning, design and development phases of most RPMTSSs. For example, even though Pinnock and McKinstry [13, p. 190] found that "successful implementation of telehealth-care programmes in rural and remote settings is contingent upon technical, organisational, social and legal considerations at the individual, community and system levels"; it does not seem that these factors are given priority during the design phases of RPMTSSs. Successful interventions are more likely to be those the design of which, included the consideration of above factors. Walker et al. [14, p. 84] concluded that patients' fear of being lost in data may explain reported limited adoption and long-term adherence to remote monitoring and suggested that "remote monitoring devices may benefit from a user-centred design approach that incorporates the patient preferences, requirements and needs." Other authors such as [4], [5], [7], [15] and [16] highlighted similar challenges.

However, Wickramasinghe and Bodendorf [17, p. 24] recently posited that in order to realize technology's full potential in this regard, "it is imperative to understand the healthcare-technology paradigm, develop sustainability models for the effective use of technology in a 'specific' context, then successfully design and implement 'patient-centric' technology solutions which are sufficiently precise, easy to use and available or accessible to the general public." Moreover, Straub [19] who reviewed the most prevalent technology adoption theories, made the following three key observations:

- a. technology adoption is a complex, inherently social, developmental process;
- b. individuals construct unique (but malleable) perceptions of technology that influence the adoption process;
and
- c. successfully facilitating a technology adoption needs to address cognitive, emotional, and contextual concerns.

In this paper, we argue that above conclusions may suggest that in addition to research efforts focusing on assessing barriers and challenges related to functional efficacy and cost-effectiveness of RPMTSSs, more

research efforts need to be directed towards understanding the specific contexts within which, these systems and tools are to be deployed prior to and during the early phases of their design and development, especially in low-income countries, rural settings and areas with limited financial resources [7], [13].

Such focused research on a particular, specific healthcare context may include aspects related to existing local ICT infrastructure, clinicians and users' perceptions and attitudes toward proposed RPMTS interventions, potential users' socio-economic circumstances, RPMTSs' impact on clinicians current work practices, preferred components, features and uses of RPMTSs as well as their technical and economic feasibility [20], [21]. Pragmatic studies of this nature could help designers determine the unique, local bundle of health benefits and related cost savings that RPMTSs are likely to deliver to a particular group of users and clinicians in a given demarcated area and context, before or at least during the design and development phases of RPMTSs[7], [22]. Therefore, the aim of this review is to assess whether the development of a research-based framework to guide localized, in-community, integrated, RPMTSs' design and development processes may ultimately alleviate the current poor adoption and limited scalability of RPMTSs.

In the following section, we introduce the methods used for the scoping study (See section 2) after which, the findings and results of the review are presented in section 3. We then discuss the implications of our findings in Section 4 and reflect on the limitations of the study in Section 5. Finally, we draw our conclusions and recommendations in Section 6.

Methodology

Focus and study placement

It is generally accepted that when a diagnosis is done accurately and early, a patient has the best opportunity for a positive outcome and the benefits of medical prognosis are well documented [25]. Yet, the above diagnosis is only triggered by a patient who experiences a health problem, considers his or her symptoms without the necessary medical expertise, and decides to engage with the healthcare system, which may be too late. Furthermore, healthcare facilities currently use different, distinct methods and technologies to detect and diagnose health conditions and diseases. These technologies or methods tend to be generally fragmented, focused on a single health issue or condition, available only at healthcare facilities and are generally reactive rather than pre-emptive in nature. Their equivalent eHealth solutions also seem to be fragmented and often targeted at a single disease or condition [10], [15], [22], mainly focused at specific sections of the population (ex. elderly or young patients) and as already stated, are often criticized for the persistent lack of adoption and scope for scalability [2], [3].

In this review, the researchers followed the preferred reporting items for systematic reviews and meta-analyses extension for scoping reviews (PRISMA-ScR) and adapted it to evaluate the adoption and scaling of RPMTS interventions. We report on 18 out of the 22 PRISMA-ScR's reporting items. However, as suggested by Leonard, de Kock and Bam, barriers and facilitators to the adoption and scaling of RPMTS interventions do not all have equal impact on the adoption and scaling of RPMTSs as some factors have a much bigger impact than others in this regard [26]. Therefore, prior to the study, the researchers analysed factors identified in [4], [5], [26], consolidated and placed them into six major categories (see appendix 1).

These main categories included: Stakeholders' Interests, contextual understanding, existing local ICT infrastructure, design approach, triggers for use and adoption as well as post-deployment assessment factors.

The resulting consolidation of above factors is displayed in the cause-effect diagram in Figure 1.

Given that existing, local ICT infrastructure, stakeholders' interests and RPMTSs' post-evaluation factors may all be considered as part of contextual understanding to be studied before the design and development of new RPMTSs, this review focused on 'triggers for use and adoption' as well as 'the design approach' in addition to 'contextual understanding'. To further focus on key 'drivers' or 'levers' along the 3 categories of interest, specifically in pre-primary and primary care settings, and attempt to use those levers to reduce barriers while enhancing facilitators, factors in the same categories of interest were compared to each other and only one factor was selected. Thus, three key levers considered to be the most influential in this study are listed below:

- Careful contextual research, prior to design and development of RPMTS interventions (particularly deep contextual understanding of a catchment area and its existing ICT infrastructure),
- targeting a combination of local diseases, rather than a single disease and
- adopting a user-centred or patient-centric design to facilitate automatic or semi-automatic integration into traditional clinical workflows.

In order to obtain a general understanding of the context in which a user-centred or patient-centric design framework targeting a combination of local diseases, prevalent in a given catchment area might improve the adoption and scalability of RPMTSs and consequently increase the quality of and access to primary healthcare services; recent literature on modern remote patients' health management systems and tools was accessed and reviewed with a view to assessing their current design, development and use with regards to six key variables listed in table 1 below:

Table 1: Dimension and variables considered

Dimension/Variable	Description	Practical relevance to the review
Positioning within the healthcare domain or industry	Space where the intervention is located (Emergency, preventative, primary care, hospital, and post-hospital).	Some areas of the healthcare domain may lend themselves to RPMTSs than others (Less regulated, more easily conceivable, acceptable or convenient).
Levels of integration within existing clinical workflows	The extent to which traditional healthcare facilities are involved or linked with end users (Patients & potential patients).	To reduce the care burden on traditional healthcare systems, the intervention has to facilitate service delivery within the community (at health centres, clinics, hospitals or home based care).
Function versatility	Diversity of measured vital signs and number of diseases targeted.	The greater the number of diseases targeted and the greater the variety of functions (measured vital signs) performed by an RPMTS intervention, the better the chances for its adoption and scaling.
Accessibility to the general public	Availability, affordability and ease of use.	The more accessible an RPMTS intervention is; the more adoptable and scalable it is likely to be.
Main intervention's purpose set by the owner organisation	Prognosis, diagnosis, wellness, monitoring or emergency alerts.	The better an RPMTS intervention meets the needs of its owners (healthcare organisation); the greater the chances of it being promoted and supported by management and healthcare workers.
Main design approach	A user-centred approach versus technically and -/ or otherwise driven.	The more the users are involved in the design of an RPMTS intervention; the greater its chances of meeting users' needs and hence, easily adoptable by them

Eligibility criteria and information sources

The researchers defined article search strategy and parameters. A choice was made to conduct one search but two reviews: one review of systematic reviews and another review of primary articles to try and confirm the validity of results. First, the inclusion and exclusion criteria were defined for the review of systematic review articles. In addition to being systematic reviews, articles were included if they:

- Involved the use of ICT between healthcare professionals and patients or their representatives,
- had the objective of assessing the adoption or scalability of RPMTSs, increasing access to healthcare services, improving the quality of care and or reducing healthcare costs and
- related to interventions which integrated into or with traditional healthcare systems (community health centres, clinics and hospitals).

Non-recent systematic review articles were excluded, if they were published before 2012, did not involve any type of remote patient management intervention or such an intervention was used exclusively within the boundaries of healthcare facilities (through WiFi, LAN, and telephone) without the involvement of offsite, end-users (patients, their representatives and potential patients) via the broader ICT infrastructure (WAN, MAN, satellite, GSM and IoT).

Second, the researchers defined additional, but slightly different inclusion and exclusion criteria for primary articles to supplement systematic review articles. Included articles were those which:

- discussed some use of a mobile/web application by end-users (patients, their representatives and potential patients),
- their main objective included prognosis, diagnosis or monitoring of diseases and or prescheduling of visits to healthcare facilities (not just alerts) and
- integrated into or with traditional healthcare systems (communication with healthcare workers to improve service delivery within a healthcare facility).

Primary articles were excluded if they were published before 2014, did not involve the actual design, development, deployment, implementation or at least the evaluation or some proposal of a remote patient management system or such a system was used exclusively within the boundaries of healthcare facilities (through WiFi, LAN and telephone) without the involvement of end-users (patients, their representatives and potential patients) via the broader ICT infrastructure (WAN, MAN, satellite, GSM and IoT).

To obtain a general overview of the six key variables or angles of the targeted gap by surveying the literary landscape in the field of RPMTSSs, one of the researchers looked for relevant articles in PubMed, MEDLINE, PMC, Cochrane databases and grey literature on google by combining a number of relevant terms and phrases as shown below:

Table 2: Search strategy (with PICO)

Search terms and phrases		
Problem/Population	P	Remote primary care, potential patients, clinic's catchment area, remote consultation, telenursing, telemedicine, online systems, primary health care, integrated delivery of health care and integrated primary care systems.
Intervention	I	Remote patient monitoring, remote sensing technology, patient health, monitoring systems, integrated system health management, integrated advanced information management systems, development of condition-based management, self-diagnosing AI technology, digital health technologies and patient monitoring system.
Comparator (Current adoption and scaling of RPMTSSs)	C	Health information systems, point-of-care systems, clinical decision support systems, health systems plans, systems integration, systems analysis, patient identification systems, data systems and learning health system.
Outcome of Interest	O	Desired (<i>No search terms</i>)

Search, screening and selection of articles

As can be seen in the figure below, a total of 2,826 articles were originally found from the above mentioned databases. Based on titles alone, 1389 articles were considered irrelevant to the subject of interest and 1382 articles remained after removing duplicates. The researcher doing the selection further excluded 1257 articles based on abstract readings and in the end only 125 articles were subjected to full-text review and inclusion and

exclusion criteria applied as previously indicated. In the end, 26 systematic reviews and 30 primary articles were deemed relevant for the scoping review at hand. 69 articles either did not meet the inclusion criteria or were excluded because they met the exclusion criteria as had been stipulated. The researchers finally focused their attention on the remaining 56 articles, starting with the 26 systematic reviews.

Data extraction

Each reviewed article was read in full and assessed based on the six variables of interest (position, integration, versatility, accessibility, main purpose and design approach) and the research question being addressed.

As depicted in Figure 3, where information relevant to a variable of interest was identified, it was extracted and tabulated for later content analysis to derive dominant patterns and trends which, were thought to potentially be relevant in ultimately addressing the topic of interest (see Appendix 2).

Findings And Results

RPMTS Positioning in the Healthcare landscape

Even though many reviews could not neatly fit in one healthcare setting, 14 out of the 26 systematic reviews (SR) included remote monitoring systems positioned in post-hospital care settings. As can be seen in Figure 3, most of the above systems had been deployed to monitor chronic conditions, previously diagnosed within hospitals and had been deployed in the context of continuity of care including detecting signs of deterioration or improvement in chronic disease, treatment or rehabilitation, patient's advice, support, education or training, medication adherence and cost reduction in hospitalization.

Ten articles [4], [12], [18], [29], [30], [31], [32], [33], [34] and [35] dealt with interventions that could be clearly classified as falling into the preventive, pre-clinical or hospital, emergency and/or primary care settings. The majority of the above articles, except [30], [31] and [34] combined the above setting with other settings such as the hospital or post-hospital monitoring. And as can be seen in Figure 3, four articles [4], [12], [18] and [29] were both in the preventive and primary care settings without the involvement of any hospital or post-hospital monitoring.

For the 30 primary articles (PA) considered, 12 articles [3], [36], [37], [38], [39], [40], [41], [42], [43], [44], [45] and [46] were classified as falling into the preventive, pre-clinical or pre-hospital, emergency and or primary care settings of the healthcare landscape. Eight of the above mentioned 12 articles [36], [38], [39], [40], [41], [42], [43] and [46], combined the above setting with other settings such as the emergency, hospital or post-hospital monitoring. Five articles [3], [37], [40], [41], and [43] discussed interventions in which, preventative measures were implemented in primary care settings and two additional interventions [44] and [45] were set in the educational, preventive, pre-primary settings. Therefore, as demonstrated in Figure 4, a total of 7 articles were both in the preventive and primary care settings.

Levels of integration within traditional healthcare systems or facilities

Integration here refers to the degree to which an intervention facilitates existing clinical work or improves existing clinical workflows [5], [34]. A significant number of systematic reviews (nine) did not contain information about the extent to which discussed interventions integrated or intended to integrate with /- into traditional healthcare systems. Of the 26 reviews, 9 [4], [9], [12], [24], [29], [47], [31], [48] and [49] provided information to suggest or demonstrate that above integration was either achieved or at least attempted.

Furthermore, in the majority of above 9 cases, 'integration' simply meant communication with one or more healthcare professionals via phone or video conferencing and not necessarily integration into clinical workflows. This spread can be viewed in Figure 5.

In the remaining 8 reviews [2], [5], [11], [18], [34], [35], [50] and [51] discussed interventions were partially integrated into traditional healthcare systems and highlighted challenges which hampered complete integration into clinical workflows. For example, one review [34] identified two key barriers to integration: the 'diversity of available technologies' and 'lack of comprehensive guiding framework for standardizing data collection and integration'. One review [2] pointed to the use of non-scalable and silo solutions which suffer from the absence of interoperability and clinical acceptance to facilitate user engagement and self-management of chronic diseases. Other reviews highlighted additional concerns affecting integration with traditional healthcare systems.

One of the above reviews [5] indicated that healthcare practitioners view some effects of mHealth on aspects such as their credibility and autonomy as impacting their acceptance of such tools and systems; while another [35] highlighted the lack of integration of community-based HIS in formal HMIS (without complete integration, there are duplicative efforts in data collection, analysis, and reporting), and the lack of technical capacity of community workers. Finally, review [51] observed that despite the huge research effort on remote care technology, there has not been a sufficient number of successful interventions which have gone past the research environment and broadly taken up and routinely used in clinical settings.

With regards to primary articles, the picture was similar. Eleven articles did not provide sufficient details to determine the extent to which, considered interventions integrated or intended to integrate into traditional healthcare systems. As demonstrated in Figure 6, in 10 of the 30 articles [20], [37], [41], [42], [52], [53], [54], [55], [56] and [57], there was sufficient information to establish that integration with traditional healthcare facilities had at least been considered. Again, in most cases above integration was limited to audio or video communication with healthcare providers or some alert mechanisms. 9 of the 30 articles [22], [58], [38], [44], [46], [59], [60], [61] and [62] provided evidence of limited integration into traditional healthcare systems and three in particular [22], [58] and [60] highlighted the significant potential that could be realized if discussed interventions were integrated into existing EMR -/ EHR.

Functional versatility (number and nature of targeted diseases)

Systematic reviews generally discussed multiple diseases targeted with different, but often independent interventions. As demonstrated in figure 7, half of the reviews [2], [4], [10], [12], [24], [29], [31], [32], [35], [47], [49], [63] and [64] discussed multiple diseases but were largely not specific to any one disease. Five [4], [10], [24], [31] and [63] actually identified diseases they targeted by name and the remaining 8 were not specific to any particular disease. Of the above 8, three [4], [12] and [29] involved audio or video conference engagements with patients, allowing them to discuss or target a broad range of unspecified conditions or diseases. However, 8 reviews [8], [9], [11], [30], [33], [34], [50] and [51] out of 26, targeted only one disease such as diabetes, COPD, or asthma, and 3 reviews [8], [30] and [33] discussed interventions related to cardiovascular diseases. The remaining 5 reviews did not provide sufficient details to determine whether they targeted one or more diseases. Most of these simply monitored vital signs but were not clear about the targeted disease(s). Where multiple diseases were manifestly targeted in a particular systematic review, it was often not clear whether a combination of diseases was targeted by the same or different RPMTs.

The picture was quite different with regards to primary articles (See PA in Figure 7). Of the 30 articles reviewed, 22 articles [58], [20], [36], [37], [39], [40], [41], [42], [46], [52], [53], [54], [55], [56], [57], [59], [61], [62], [65], [66], [67] and [68] discussed interventions which targeted one, single disease. Targeted diseases ranged from PTSD, mental health, Parkinson disease, COPD to IBD and malaria. The remaining 8 articles [22], [15], [3], [38], [43], [44], [45] and [60] tended to cover a combination of diseases but only three [38], [44] and [60] were specific about the combination of diseases or parameters they sought to monitor or measure (HIV/AIDS and TB, and parameters related to CVD or COPD).

Accessibility to the general public

While a number of systematic reviews did not provide enough details to determine the extent to which, discussed interventions were accessible to the general patient or potential patient population, the majority [4], [9], [10], [11], [12], [14], [18], [23], [24], [29], [31], [32], [34], [48], [49], [50], [51], [63] and [64] provided information which indicated that accessibility was limited as depicted in Figure 8. Among the many mentioned factors which negatively affect accessibility were usability, integration between patients and electronic health records, and giving personalized feedback [4], [63], centralized and decentralized data problem, which is a source of confusion and poses security and privacy challenges [32], performance in clinical settings is still controversial [31] and insufficient healthcare infrastructure and funding [11], [29].

Other reviews, however highlighted more systemic and historical challenges including those related to inequalities and the needs of the target use group which ought to be taken into consideration early in the design and development of mhealth tools; vulnerable, hard-to-reach, or otherwise high-risk patient populations [10], [34], [48], [49] and [64]; varying degrees of literacy, connectivity and accessibility and some patients who were concerned that their care would become dependent on technology, resulting in depersonalised care, reductions in face-to-face interaction, and increased out of pocket costs [14], [18]; characteristics of the care setting and circumstances surrounding individual patients such as rural vs urban, in or out-patient, care delivery & payment models, patient's characteristics and care goals and preferences.

Studies of telehealth should consider combinations of apps of telehealth and outcomes that are important in these new models and that evaluate the specific contribution telehealth can make in these contexts [24] and

review [23] pointed out that prior to deploying a newly developed intervention into healthcare settings, its practicality, clinical effectiveness and potential commercial benefits ought to be established and backed up by concrete evidence.

Primary articles also displayed similar results. Of the 30 articles, only three [40], [43] and [45] provided information which indicated that accessibility of the intervention to the general public had been considered or was at least desired. Eight articles did not provide details related to accessibility. As depicted in Figure 8, the majority of articles [22], [58], [3], [36], [38], [39], [41], [42], [44], [46], [55], [56], [57], [60], [61], [62], [66], [67] and [68] gave various reasons why accessibility of discussed interventions was limited including scalability [3], [36] health apps and smart phones' credibility for continuous data flow, feasibility, portability, and power consumption [58], [39], [44] and [66], limited or lack of training [42], limited connectivity and internet requirement of systems [41], and failure to take into account natural variations in patient physiology or behaviour [62]. Other mentioned factors were similar to those covered by systematic reviews.

The main purpose of interventions

The large majority of systematic reviews discussed interventions which included patient monitoring for various purposes, ranging from reporting worsening symptoms of chronic diseases such as Heart failure, COPD, asthma, infectious diseases to patient triage (see Figure 9).

In some cases [4], [29], [30], [32], [33], [35] and [47], monitoring was combined either with prognosis or diagnosis of various diseases. In relatively few cases [2], [11], [12] [18] and [49], reviews discussed interventions which exclusively focused on prognosis, diagnosis or triage of patients without the requirement of continuous patient monitoring as part of the intervention. In the remaining 14 cases, reviews discussed interventions whose purpose was either or a combination of communication, wellness and emergency alerts in addition to patient monitoring.

As far as primary articles were concerned, the vast majority of articles (20) discussed a combination of monitoring, communication, wellness and emergency alerts either for assessing the severity of symptoms of pre-existing health conditions or to manage patient's adherence to treatment. However, as shown in Figure 10, one article [3] discussed on-demand monitoring for triage purposes and only hinted at prognosis and diagnosis but did not clarify its level of integration with traditional healthcare systems. In the remaining cases [36], [37], [40], [41], [43], [45], [46], [65] and [68], prognosis and or diagnosis were mentioned along with continuous patient monitoring for vital signs. Overall, most articles were clear about their main purpose.

Design and Implementation approach

Of the 26 systematic reviews considered, only one review [9] discussed an implementation which, placed patients at its centre, providing training, educational materials and daily phone calls to support patients. In seven reviews [8], [2], [23], [32], [33], [63] and [64], the design was considered to be more technically centred, with patients and potential patients simply being expected to adopt the designed solution.

Nine reviews [5], [14], [24], [30], [31], [34], [48], [49] and [51] gave evidence of wishing to pursue a user-centred design but there was an indication that such design was either not achieved or was limited due to factors such as unavailability of mHealth apps on some operating systems [49], limited mobility and flexibility, in addition to the trustworthiness and quality of the content, and personalization possibilities through customization and adaptability [5], usability drawbacks, as well as reports of the need for more comprehensive solutions, including the provision of real-time feedback and the integration of the EHRs systems being used by the care providers [51]. The layout of design approach for systematic reviews is depicted in Figure 11.

With regards to primary articles, five articles [15], [20], [46], [58] and [62] of all articles set out to pursue a user-centred design from the outset of intervention design by broadly consulting clinicians and patients. As can be seen in Figure 12, seven considered articles [37], [39], [43], [57], [61], [66] and [68] were deemed to have pursued a technical rather than a user-centred design and several of the considered articles discussed off-the-shelf solutions which required customization. However, even though most of the articles were silent about the design approach overall, the importance of a user-centred or patient-centric approach was broadly acknowledged to facilitate adoption by end-users, in the vast majority of reviewed primary articles.

Analysis And Discussion

Table 3: Summary of evidence (findings and implications)

Dimension	Findings	Observations & Implications for research
Position	The majority of RPMTSSs are deployed in post-hospital settings to monitor chronic conditions, previously diagnosed within hospitals. Few RPMTSSs are deployed in pre-clinical settings for preventive, prognostic or diagnostic purposes.	While the increasing prevalence of chronic diseases in aging populations is the main driver for the rapidly increasing use of RPMTSSs, deploying RPMTSSs in remote, automated prognosis, preliminary diagnosis and prescheduling of visits to healthcare facilitates has significant potential for the prevention and early detection of above diseases and therefore ought to receive adequate research attention.
Levels of integration	RPMTSSs deployed in post-hospital settings are generally integrated into existing clinical workflows. However, RPMTSSs deployed in pre-hospital and primary care settings are often not integrated into existing clinical workflows (e.g. quantified-self apps).	RPMTSSs can only help reduce the care burden on traditional healthcare systems when they are linked to them. There is therefore a need to consider integration into existing clinical workflows as a key requirement when designing RPMTSSs for deployment in pre-clinical and primary care settings.
Functional versatility	While RPMTSSs used in the management of chronic diseases are mostly targeted at a single disease and its related vital signs, the few RPMTSSs found in pre-clinical settings are generally versatile and tend to focus on a combination of diseases.	Even though addressing multiple diseases with a single RPMTSS intervention might improve its likelihood for adoption, there is a need for increased built-in, interpretive capacity to avoid expecting untrained users to make sense of resultant information on their own, without the necessary skills to do so (automatic interpretation of medical data is critical).
Accessibility	Accessibility is generally limited: Interventions in the preclinical and primary care settings are severely hampered by the lack of legal frameworks as well as issues related to information privacy and security and those in post-hospital settings for the monitoring of chronic conditions generally focus on a single disease.	In post-hospital settings, the focus on a single disease means that only patients who suffer from the targeted disease can be addressed, thus limiting the scope for adoption and scaling. For RPMTSSs contemplated for pre-clinical settings, there is a need to work with policy makers to develop a legal framework and policies not only to address ethical and safety issues but also those related to information privacy and security.
Main intervention's purpose	Healthcare organisations are mainly driven to utilise RPMTSSs to manage the increasing care burden resulting from the rapid rise in chronic conditions. They are used in an attempt to reduce the resulting skyrocketing care costs around the world.	The end-goal is not management but cost and work load reduction. Prevention could be less costly than treatment. By using RPMTSSs to boost disease prevention and early detection, some diseases might be entirely avoided and the costs of managing chronic conditions might be significantly reduced.
Main design approach	The benefits of a user-centred or patient-centric design approach are widely acknowledged to promote adoption and scaling. However, in less than half of RPMTSSs' design cases, a user-centred or patient-centric approach is pursued.	Involvement of users in the conceptualisation and design of a new RPMTSS is a key driver for its subsequent adoption. Therefore, designers interested in the adoption and scaling of their RPMTSSs ought to find a systematic way or method of allowing users to shape the design and deployment of their contemplated RPMTSSs.

A summary of findings along each of the six dimensions of analysis is provided in table 3 along with observations and implication for future research directions. From our scoping review of the landscape of

RPMTS's design, development and deployment, it appears that the majority of RPMTS interventions deployed in the pre-clinical setting for preventive purposes and known as 'self-diagnosing apps or symptom checkers' have not been found to be integrated into traditional clinical workflows. These interventions [18], [30], [34], [37], [42], [43], [44] and [45] are mainly deployed to monitor patients' physical activities (PA) to address lifestyle related diseases such as cardiovascular diseases (CVD), high blood pressure and diabetes in the context of the new 'quantified self' movement.

Reviewed literature, however indicates that individual users -/ potential patients are often not able to make sense of the resultant health information to assess its applicability and impact on them, which could negatively affect their overall wellbeing and general health [18]. An integrated framework could, therefore not only facilitate the integration of the quantified self's tools into existing clinical workflows but also increase their functional utility to traditional healthcare systems.

The literature on the design and deployment of RPMTS shows that these interventions do not consistently follow 'a user-centred approach' which is in line with the fragmented [15], direct to consumer models used to target those who are interested in their physical fitness and wellbeing [18]. With regards to above initiatives and their potential to improve health outcomes, Cornet and Holden [30], recommended that specialists (e.g., informaticists, computer scientists, etc..) should collaborate with clinical experts to identify and address problems amenable to passive sensing and indicated that only through these kinds of partnerships can novel technologies be designed and assessed for practical value, scalability, and sustainability. Thus, an organising framework to promote these collaborative engagements could contribute to the increased adoption and scaling of RPMTSs. RPMTS interventions deployed in the pre-clinical setting also suffer from a lack of clear legal and policy frameworks to guide their design and deployment. For example, Hoffman et al. [42, p. 2] point to perceived barriers which "can include concerns about privacy, legal ramifications, cost, workload, and need for increased information technology (IT) support."

The above reality could be the logical reason for Lobelo et al. [34, p. 10] to have concluded their systematic review by recommending that stakeholders should "work collaboratively to address privacy/security concerns and standardize frameworks to ensure reliability, validity and utility for PA promotion and CVD risk reduction applications in clinical and community settings, as well as population health management and public health advancement". Therefore, notwithstanding other possible limitations, legal and policy gaps along with the currently fragmented, direct to consumer deployment models, may partially explain the absence of integration of these types of RPMTSs into traditional healthcare systems.

The proposed framework would aid in bridging above gaps and fragmentation especially in remote, automated prognosis, preliminary diagnosis and prescheduling of health related appointments away from healthcare facilities. Indeed, as posited by Jacob, Sanchez-Vazquez, and Ivory, mHealth systems ought to continue to "help shift the focus of health care to a more patient-centric model that goes beyond treating disease to a more predictive and preventative approach" [5, p. 2].

While the majority of RPMTS deployed in pre-clinical settings for preventive purposes were generally versatile and could gather symptoms about different diseases, it appears that users and their physicians are expected to discern the health implications for the generated health-related information which, inadvertently increases the burden on patients/potential patients and their clinicians. Yet, as pointed out by Walker et al., technology

should “be designed to have minimal user burden, be user-friendly, and have mechanisms installed to provide reassurance of safety” [14, p. 84]. The advent of a well-integrated framework could encourage designers and developers of RPMTSs to avoid placing unnecessary burdens on users by paying careful attention to above critical drivers of adoption.

On the clinician’s side, Jacob, Sanchez-Vazquez, and Ivory [5, p. 16] concluded that “integrating mHealth in the clinical workflow is key to avoid that the tools become more of a hurdle to the staff”. Furthermore, speaking about difficulties encountered by clinicians in triaging patients for care, Kalid et al. [3, p. 11] observed that “the overwhelming heterogeneous data cause difficulty in deciding which patient out of many should be provided with care first” and concluded that “decision-based methods for prioritising patients in this environment are of urgent concern” and Totten et al. [24] identified triage in urgent/primary care settings as a potential area of primary research to assist clinicians in their work. Therefore, designers of RPMTS ought to pursue completely automated, value adding processes and tasks which require minimal or no user and or clinician’s involvement or intervention. The proposed framework could foster the above efforts.

However, for emergency, hospital and post-hospital settings, it was found that RPMTS generally focus on a single disease in the context of continuity of care (in home settings). In fact, Gray et al. found that some of the key weaknesses identified in Canada’s eHealth programs to support people with complex care needs included the fact that “most technologies focus on single disease populations with few meeting the needs of “high users”, and there are few instances of links between healthcare and social-care organizations, making it difficult to wrap a full range of services and support around individuals who need them” [22, p. 31]. Targeting RPMTS initiatives to Individuals who might need the same range of healthcare services however, might require the design and deployment of RPMTS solutions for or in specific locations or areas rather than for specific diseases to meet the requirement of high number of users.

Nevertheless, it is evident that the number of diseases targeted by any one, specific RPMTS intervention has a bearing on the general public’s accessibility to that intervention and ultimately affects its adoption and potential for scalability. As suggested by the reviewed literature, more than 70% of RPMTSs target a single disease and are deployed in post-hospital settings to address the growing list of complex, chronic diseases and disabilities.

The general public’s accessibility to these interventions in these contexts is thus, inherently constrained and limited to those patients who suffer from the targeted disease and would naturally result in limited adoption and scalability. Therefore, notwithstanding all other relevant factors, levels of adoption and scalability in single disease cases ought to be assessed in the context of the small population of concerned caregivers and patients who suffer from the targeted disease. In contrast, a move to address a combination of diseases, prevalent in a given, specific catchment area could potentially increase the much needed adoption and scalability of RPMTSs, especially in developing countries.

As concluded by Totten et al., going forward, new research efforts should focus on emerging models of care, particularly value-based models where the use of telehealth may improve the ability to share risk and attain better quality and related outcomes. “These studies of telehealth should consider combinations of applications of telehealth and outcomes that are important in these new models and that evaluate the specific contribution telehealth can make in these contexts” [24, p. 52]. Since heeding the above conclusion might lead to increased

accessibility, adoption and scalability of RPMTSs in general, an integrated framework is needed to help design and develop multi-functional RPMTSs.

Reviewed literature has expressed support for patient-centric or user-centred RPMTS' design, development and deployment approaches. Yet, more than half of the reviewed RPMTS interventions did not give evidence of having pursued a user-centred approach. To highlight the existing gap between users or patients' real needs and existing RPMTSs, Rudin et al. [58, p. 1032] observed that "of the more than 165,000 mHealth apps available, many have low usability, do not provide clinical utility, have minimal uptake, or are abandoned soon after first use. Few are designed to be integrated into clinical workflows, even those that are highly rated. Little is known about how to develop mHealth functionality that will not only provide clinical utility for chronic condition management but also will be adopted and used by patients and providers".

Above reality may partially explain the current low rate of adoption of RPMTSs, despite existing enthusiasm and hype around these interventions. It would thus be a good idea to further explore and possibly embrace the 3 key lessons set out by Smaradottir, Gerdes and Fensli [20, p. 358] which are that "intended solutions for medical environments necessarily need to firstly involve all the user groups in the creation of the solution.

Secondly, the respective analysis of how this solution could best fit in an existing clinical workflow or, if non-existent, embedding the solution in a new workflow built up in collaboration with the end-user groups.

Thirdly, chronic patients do not have the same levels of physical energy as healthy people underlines the importance of designing easy-to-use solutions that minimise physical effort and mental workload". Therefore, from the above discussion, the application and use of a user-centred, context-dependent, customizable framework focusing on a combination of diseases prevalent in a given catchment area could enhance improved design and deployment of RPMTSs and increase their adoption and scaling, especially in primary care contexts. Figure 14 depicts the conceptual analysis leading to these findings.

Limitation Of The Review

This particular review has significant limitations. First of all, only one researcher did the refinement of the research question, data extraction and the synthesis of evidence. Secondly, the researcher in question did not review the academic quality and rigour of the included and reviewed articles. It should also be noted that reviewed literature is not necessarily statistically representative of the healthcare landscape in all countries.

Interestingly, Kristoffersson and Lindén [33] who also very recently reviewed literature on the use of wearable body sensors for health monitoring, highlighted a number of significant shortcomings in published articles between 2010 and 2019, including small sample sizes (only 20% of the studies involve more than 100 participants), poor presentation (not providing enough or sufficient information on how the experiments were conducted); and using non-representative participant demographics or not providing information on representative participant demographics (age, gender, patient/healthy, etc..).

In this particular scoping review, there has also been a deliberate exclusion of relevant articles published before 2012 for systematic reviews and those published before 2014 for primary articles. Considered articles also varied greatly in their nature and extent to which they provided insights into variables of interests and resultant

implications for answering the research question of interest. Therefore, subjective extraction and evidence synthesis methods employed by the researcher may have impacted his perception and understanding.

All of these factors might indicate some degree of bias and may have significant implications for the validity of drawn conclusions and recommendations. Added to this, are the limitations, normally associated with scoping reviews. Some of these limitations are summarized in the table below:

Table 4: General limitations of the scoping review

	Potential Bias/Issues
Review by one researcher	Reduced transparency and reproducibility,
Only one reviewer extracting data	Increased risk of errors and missing key, relevant points,
Considering only recent articles	Key articles and results could be excluded,
Excluding non-English publications	Important studies/reviews in other languages may have been missed
Limited access to relevant databases	Key articles may not have been considered due to inaccessibility
Flexible Review/Study design	Reduced accuracy, validity and possible bias

Conclusions And Future Work

The completed scoping review has suggested that identified levers may indeed play an important role in improving the adoption and scalability of RPMTSs. No single article discredited any of the identified levers (contextual understanding, combination of diseases in a given catchment area and a user centered design approach), while the vast majority of reviewed publications pointed to the importance and utility of the proposed framework to entrench identified levers in the conception, design, development and deployment of RPTMSs. Therefore, based on reviewed, recently-published material, It seems likely that the application and use of a user-centred or patient-centric, context-dependent, customizable framework, may assist in increasing the adoption and scalability of RPMTSs, if such framework addressed a combination of diseases, prevalent in a given, specific community or catchment area.

Although reviewed publications did not directly address the process through which the proposed framework would improve RPMTS's adoption and scalability, this review has shown that such a framework would be able to assist RPMTS's designers and developers to address issues most likely to influence adoption and scalability during or prior to planning and designing such RPMTSs, by carefully studying the contexts within which prospective RPMTSs will be subsequently deployed and by engaging target users. The extent of the increase in adoption and scalability was not addressed but would obviously depend on how well target users and their specific contexts are understood by RPMTS's designers and developers.

Based on the above conclusions and previously stated limitations of this review, it is recommended that future research efforts be directed towards the design of a research study (or studies) to develop the proposed

framework and determine how such a framework, once developed, can be tested and validated in the field to achieve desired outcomes.

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Authors' contributions:

All authors created the study concept and design. The principle author collected, analysed and interpreted the data and drafted the paper, while the two authors iteratively reviewed the work and recommended multiple changes to the manuscript. All authors have approved the final version of the manuscript.

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References

1. The Seventy-first World Health Assembly, "Digital health," Geneva, 2018. Accessed: Mar. 11, 2020. [Online]. Available: https://apps.who.int/gb/ebwha/pdf_files/WHA71/A71_R7-en.pdf.
2. M. M. Baig, H. GholamHosseini, A. A. Moqem, F. Mirza, and M. Lindén, "A Systematic Review of Wearable Patient Monitoring Systems – Current Challenges and Opportunities for Clinical Adoption," *J. Med. Syst.*, vol. 41, no. 7, 2017, doi: 10.1007/s10916-017-0760-1.

3. N. Kalid, A. A. Zaidan, B. B. Zaidan, O. H. Salman, M. Hashim, and H. Muzammil, "Based Real Time Remote Health Monitoring Systems: A Review on Patients Prioritization and Related 'Big Data' Using Body Sensors information and Communication Technology," *J. Med. Syst.*, vol. 42, no. 2, 2018, doi: 10.1007/s10916-017-0883-4.
4. H. K. Y. Almathami, K. T. Win, and E. Vlahu-Gjorgievska, "Barriers and Facilitators That Influence Telemedicine-Based, Real-Time, Online Consultation at Patients' Homes: Systematic Literature Review," *J. Med. Internet Res.*, vol. 22, no. 2, p. e16407, 2020, doi: 10.2196/16407.
5. C. Jacob, A. Sanchez-Vazquez, and C. Ivory, "Social, organizational, and technological factors impacting clinicians' adoption of mobile health tools: Systematic literature review," *JMIR mHealth uHealth*, vol. 8, no. 2, 2020, doi: 10.2196/15935.
6. S. Yusif, A. Hafeez-Baig, and J. Soar, "e-Health readiness assessment factors and measuring tools: A systematic review," *Int. J. Med. Inform.*, vol. 107, no. December, pp. 56–64, 2017, doi: 10.1016/j.ijmedinf.2017.08.006.
7. D. B. Mueller, D. Tivey, and D. Croce, "Health-technology assessment: Its role in strengthening health systems in developing countries," *Strengthen Heal. Syst.*, vol. 2, no. 1, pp. 6–11, 2017, doi: 10.7196/SHS.2017.v2.i1.50.
8. A. Vegesna, M. Tran, M. Angelaccio, and S. Arcona, "Remote Patient Monitoring via Non-Invasive Digital Technologies: A Systematic Review," *Telemed. e-Health*, vol. 23, no. 1, pp. 3–17, 2017, doi: 10.1089/tmj.2016.0051.
9. C. Esteban *et al.*, "Outcomes of a telemonitoring-based program (telePOC) in frequently hospitalized COPD patients," *Int. J. COPD*, vol. 11, pp. 2919–2930, 2016.
10. S. Hamine, E. Gerth-Guyette, D. Faulx, B. B. Green, and A. S. Ginsburg, "Impact of mHealth chronic disease management on treatment adherence and patient outcomes: A systematic review," *J. Med. Internet Res.*, vol. 17, no. 2, pp. 1–15, 2015, doi: 10.2196/jmir.3951.
11. K. Kayleigh M and C. Christopher J, "Home telemonitoring and remote feedback between clinic visits for asthma," *Cochrane Database Syst. Rev.*, no. 8, 2016, doi: 10.1002/14651858.CD011714.pub2.www.cochranelibrary.com.
12. A. Thiyagarajan, C. Grant, F. Griffiths, and H. Atherton, "Exploring patients' and clinicians' experiences of video consultations in primary care: a systematic scoping review," *BJGP Open*, p. bjgpopen20X101020, 2020, doi: 10.3399/bjgpopen20x101020.
13. H. Pinnock and B. McKinstry, "Digital technology in respiratory diseases," *Chron. Respir. Dis.*, vol. 13, no. 2, pp. 189–191, 2016, doi: 10.1177/1479972316637788.
14. R. C. Walker, A. Tong, K. Howard, and S. C. Palmer, "Patient expectations and experiences of remote monitoring for chronic diseases: Systematic review and thematic synthesis of qualitative studies," *Int. J. Med. Inform.*, vol. 124, no. April, pp. 78–85, 2019, doi: 10.1016/j.ijmedinf.2019.01.013.
15. T. Vandenberg *et al.*, "Vendor-independent mobile health monitoring platform for digital health studies: Development and usability study," *JMIR mHealth uHealth*, vol. 7, no. 10, pp. 1–10, 2019, doi: 10.2196/12586.
16. A. S. Hameed, S. Sauermann, and G. Schreier, "The impact of adherence on costs and effectiveness of telemedical patient management in heart failure: A systematic review," *Appl. Clin. Inform.*, vol. 5, no. 3, pp.

612–620, 2014, doi: 10.4338/ACI-2014-04-RA-0037.

17. N. Wickramasinghe and F. Bodendorf, *Delivering Superior Health and Wellness Management with IoT and Analytics*. Richmond: Springer, 2020.
18. S. Aboueid, R. H. Liu, B. N. Desta, A. Chaurasia, and S. Ebrahim, "The use of artificially intelligent self-diagnosing digital platforms by the general public: Scoping review," *J. Med. Internet Res.*, vol. 21, no. 5, 2019, doi: 10.2196/13445.
19. E. T. Straub, "Understanding technology adoption: Theory and future directions for informal learning," *Rev. Educ. Res.*, vol. 79, no. 2, pp. 625–649, 2009, doi: 10.3102/0034654308325896.
20. B. Smaradottir, M. Gerdes, and R. Fensli, "User-Centered Design of a COPD Remote Monitoring Application Experiences from the EU-project United4Health," *Interantional J. Adancess Softw.*, vol. 8, no. 3, pp. 350–360, 2015.
21. S. Van Der Weegen, R. Verwey, M. Spreeuwenberg, H. Tange, T. Van Der Weijden, and L. De Witte, "The development of a mobile monitoring and feedback tool to stimulate physical activity of people with a chronic disease in primary care: A user-centered design," *J. Med. Internet Res.*, vol. 15, no. 7, 2013, doi: 10.2196/mhealth.2526.
22. C. S. Gray, S. Mercer, T. Palen, B. Mckinstry, and A. Hendry, "eHealth Advances in Support of People with Complex Care Needs: Case Examples from Canada, Scotland and the US," *Healthc. Q.*, vol. 19, no. 2, pp. 29–37, 2016.
23. H. S. Kim *et al.*, "Future prospects of health management systems using cellular phones," *Telemed. e-Health*, vol. 20, no. 6, pp. 544–551, 2014, doi: 10.1089/tmj.2013.0271.
24. A. MTotten *et al.*, "Telehealth: Mapping the Evidence for Patient Outcomes From Systematic Reviews," no. 26, 2016.
25. E. P. Balogh, B. T. Miller, and J. R. Ball, *Improving Diagnosis in Health Care Improving Diagnosis i in Health C Care*. Washington: THE NATIONAL ACADEMIES PRESS, 2015.
26. E. Leonard, I. de Kock, and W. Bam, "Barriers and facilitators to implementing evidence-based health innovations in low- and middle-income countries: A systematic literature review," *Eval. Program Plann.*, vol. 82, no. March, p. 101832, 2020, doi: 10.1016/j.evalprogplan.2020.101832.
27. C. Schardt, M. B. Adams, T. Owens, S. Keitz, and P. Fontelo, "Utilization of the PICO framework to improve searching PubMed for clinical questions," *BMC Med. Inform. Decis. Mak.*, vol. 7, pp. 1–6, 2007, doi: 10.1186/1472-6947-7-16.
28. P. Farrugia, B. A. Petrisor, F. Farrokhyar, and M. Bhandari, "Practical tips for surgical research: Research questions, hypotheses and objectives.," *Can. J. Surg.*, vol. 53, no. 4, pp. 278–81, 2010, [Online]. Available: <http://www.ncbi.nlm.nih.gov/pubmed/20646403><http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=PMC2912019>.
29. J. P. Burnham, S. A. Fritz, L. H. Yaeger, and G. A. Colditz, "Telemedicine infectious diseases consultations and clinical outcomes: A systematic review," *Open Forum Infect. Dis.*, vol. 6, no. 12, pp. 1–6, 2019, doi: 10.1093/ofid/ofz517.
30. V. P. Cornet and R. J. Holden, "Systematic review of smartphone-based passive sensing for health and wellbeing," *J Biomed Inf.*, vol. 77, pp. 120–132, 2018, doi: doi:10.1016/j.jbi.2017.12.008.

31. E. Gonzalez, R. Peña, A. Avila, C. Vargas-Rosales, and D. Munoz-Rodriguez, "A Systematic Review on Recent Advances in mHealth Systems: Deployment Architecture for Emergency Response," *J. Healthc. Eng.*, vol. 2017, pp. 1–12, 2017, doi: 10.1155/2017/9186270.
32. M. Kang, E. Park, B. H. Cho, and K. S. Lee, "Recent patient health monitoring platforms incorporating Internet of Things-enabled smart devices," *Int. Neuroinol. J.*, vol. 22, no. Suppl 2, pp. S76–S82, 2018, doi: 10.5213/inj.1836144.072.
33. A. Kristoffersson and M. Lindén, "A Systematic Review on the Use of Wearable Body Sensors for Health Monitoring: A Qualitative Synthesis," *Sensors (Basel)*, vol. 20, no. 5, 2020, doi: 10.3390/s20051502.
34. F. Lobelo *et al.*, "The Wild Wild West: A Framework to Integrate mHealth Software Applications and Wearables to Support Physical Activity Assessment, Counseling and Interventions for Cardiovascular Disease Risk Reduction," *Prog. Cardiovasc. Dis.*, vol. 58, no. 6, pp. 584–594, 2016, doi: 10.1016/j.pcad.2016.02.007.
35. Measure Evaluation, "Community-Based Health Information Systems in the Global Context," Chapel Hill, WP-16-161, 2016.
36. G. Alfian, M. Syafrudin, M. F. Ijaz, M. A. Syaekhoni, N. L. Fitriyani, and J. Rhee, "A personalized healthcare monitoring system for diabetic patients by utilizing BLE-based sensors and real-time data processing," *Sensors (Switzerland)*, vol. 18, no. 7, 2018, doi: 10.3390/s18072183.
37. A. Börve *et al.*, "Smartphone teledermoscopy referrals: A novel process for improved triage of skin cancer patients," *Acta Derm. Venereol.*, vol. 95, no. 2, pp. 186–190, 2015, doi: 10.2340/00015555-1906.
38. L. A. Durán-Vega *et al.*, "An IoT system for remote health monitoring in elderly adults through a wearable device and mobile application," *Geriatr.*, vol. 4, no. 2, 2019, doi: 10.3390/geriatrics4020034.
39. A. J. Espay *et al.*, "Technology in Parkinson disease: Challenges and Opportunities on behalf of the MDS Taskforce on Technology HHS Public Access Author manuscript," *Mov Disord*, vol. 31, no. 9, pp. 1272–1282, 2016, doi: 10.1002/mds.26642.
40. T. M. Fernández-Caramés, I. Froiz-Míguez, O. Blanco-Novoa, and P. Fraga-Lamas, "Enabling the internet of mobile crowdsourcing health things: A mobile fog computing, blockchain and iot based continuous glucose monitoring system for diabetes mellitus research and care," *Sensors (Switzerland)*, vol. 19, no. 15, pp. 1–24, 2019, doi: 10.3390/s19153319.
41. F. Francis *et al.*, "Deployment and use of mobile phone technology for real-time reporting of fever cases and malaria treatment failure in areas of declining malaria transmission in Muheza district north-eastern Tanzania," *Malar. J.*, vol. 16, no. 1, pp. 1–14, 2017, doi: 10.1186/s12936-017-1956-z.
42. L. Hoffman *et al.*, "Augmenting mental health in primary care: A 1-Year Study of Deploying Smartphone Apps in a Multi-site Primary Care/Behavioral Health Integration Program," *Front. Psychiatry*, vol. 10, no. FEB, pp. 1–10, 2019, doi: 10.3389/fpsy.2019.00094.
43. P. Nedungadi, A. Jayakumar, and R. Raman, "Personalized Health Monitoring System for Managing Well-Being in Rural Areas," *J. Med. Syst.*, vol. 42, no. 22, pp. 1–11, 2018, doi: 10.1007/s10916-017-0854-9.
44. S. Neubert *et al.*, "Multi-Sensor-Fusion Approach for a Data-Science-Oriented Preventive Health Management System: Concept and Development of a Decentralized Data Collection Approach for Heterogeneous Data Sources," *Int. J. Telemed. Appl.*, vol. 2019, 2019, doi: 10.1155/2019/9864246.

45. M. Ponum, O. Hasan, and S. Khan, "Easydetectdisease:an android app for early symptom detection and prevention of childhood infectious diseases," *J. Med. Internet Res.*, vol. 21, no. 5, 2019, doi: 10.2196/12664.
46. K. Possemato, E. Kuhn, E. M. Johnson, J. E. Hoffman, and E. Brooks, "Development and refinement of a clinician intervention to facilitate primary care patient use of the PTSD Coach app," *Transl. Behav. Med.*, vol. 7, no. 1, pp. 116–126, 2017, doi: 10.1007/s13142-016-0393-9.
47. F. Bienfait, M. Petit, R. Pardenaud, C. Guineberteau, and A. Pignon, "Applying M-Health to Palliative Care: A Systematic Review on the Use of M-Health in Monitoring Patients With Chronic Diseases and its Transposition in Palliative Care," *Am. J. Hosp. Palliat. Med.*, no. December, pp. 1–26, 2019, doi: 10.1177/1049909119885655.
48. C. D. Q. Flumignan *et al.*, "What do Cochrane systematic reviews say about telemedicine for healthcare?," *Sao Paulo Med. J.*, vol. 137, no. 2, pp. 184–192, 2019, doi: 10.1590/1516-3180.0177240419.
49. A. S. M. Mosa, I. Yoo, and L. Sheets, "A systematic review of healthcare applications for smartphones," *BMC Med. Inform. Decis. Mak.*, vol. 12, no. 1, p. 1, 2012, doi: 10.1186/1472-6947-12-67.
50. P. A. Lee, G. Greenfield, and Y. Pappas, "The impact of telehealth remote patient monitoring on glycemic control in type 2 diabetes: A systematic review and meta-analysis of systematic reviews of randomised controlled trials," *BMC Health Serv. Res.*, vol. 18, no. 1, pp. 1–10, 2018, doi: 10.1186/s12913-018-3274-8.
51. A. Queirós, J. Alvarelhão, M. Cerqueira, A. Silva, M. Santos, and N. Pacheco Rocha, "Remote Care Technology: A Systematic Review of Reviews and Meta-Analyses," *Technologies*, vol. 6, no. 1, p. 22, 2018, doi: 10.3390/technologies6010022.
52. R. P. Benzo, K. M. Kramer, J. P. Hault, P. M. Anderson, I. M. Begue, and S. J. Seifert, "Development and feasibility of a home pulmonary rehabilitation program with health coaching," *Respir. Care*, vol. 63, no. 2, pp. 131–140, 2018, doi: 10.4187/respcare.05690.
53. N. Fell *et al.*, "Functional measurement post-stroke via mobile application and body-worn sensor technology," *mHealth*, vol. 5, no. May, pp. 41–47, 2019, doi: 10.21037/mhealth.2019.08.11.
54. E. Furlong *et al.*, "Adaptation and implementation of a mobile phone-based remote symptom monitoring system for people with cancer in Europe," *J. Med. Internet Res.*, vol. 5, no. 1, pp. 1–19, 2019, doi: 10.2196/10813: 10.2196/10813.
55. C. G. Holzmüller, S. Karp, D. Zeldow, D. B. Lee, and D. A. Thompson, "Development of a cloud-based application for the Fracture Liaison Service model of care," *Osteoporos. Int.*, vol. 27, no. 2, pp. 683–690, 2016, doi: 10.1007/s00198-015-3260-5.
56. L. L. Lefler *et al.*, "Evaluating the use of mobile health technology in older adults with heart failure: Mixed-methods study," *J. Med. Internet Res.*, vol. 20, no. 12, 2018, doi: 10.2196/12178.
57. E. L. Wallace *et al.*, "Remote Patient Management for Home Dialysis Patients," *Kidney Int. Reports*, vol. 2, no. 6, pp. 1009–1017, 2017, doi: 10.1016/j.ekir.2017.07.010.
58. R. S. Rudin *et al.*, "Core components for a clinically integrated mHealth app for asthma symptom monitoring," *Appl. Clin. Inform.*, vol. 8, no. 4, pp. 1031–1043, 2017, doi: 10.4338/ACI-2017-06-RA-0096.
59. M. Georgsson and N. Staggers, "Quantifying usability: An evaluation of a diabetes mHealth system on effectiveness, efficiency, and satisfaction metrics with associated user characteristics," *J. Am. Med. Informatics Assoc.*, vol. 23, no. 1, pp. 5–11, 2016, doi: 10.1093/jamia/ocv099.

60. J. A. Nhavoto, Å. Grönlund, and W. P. Chaquilla, "SMSaúde: Design, Development, and Implementation of a Remote/Mobile Patient Management System to Improve Retention in Care for HIV/AIDS and Tuberculosis Patients," *JMIR mHealth uHealth*, vol. 3, no. 1, pp. 1–11, 2015, doi: 10.2196/mhealth.3854.
61. A. T. Tzallas *et al.*, "Perform: A system for monitoring, Assessment and management of patients with Parkinson's disease," *Sensors (Switzerland)*, vol. 14, no. 11, pp. 21329–21357, 2014, doi: 10.3390/s141121329.
62. C. Velardo *et al.*, "Digital health system for personalised COPD long-term management," *BMC Med. Inform. Decis. Mak.*, vol. 17, no. 19, pp. 1–25, 2017, doi: 10.1186/s12911-017-0414-8.
63. L. P. Malasinghe, N. Ramzan, and K. Dahal, "Remote patient monitoring: a comprehensive study," *J. Ambient Intell. Humaniz. Comput.*, vol. 10, no. 1, pp. 57–76, 2019, doi: 10.1007/s12652-017-0598-x.
64. A. H. Sapci and H. A. Sapci, "Innovative assisted living tools, remote monitoring technologies, artificial intelligence-driven solutions, and robotic systems for aging societies: Systematic review," *J. Med. Internet Res.*, vol. 21, no. 11, pp. 1–16, 2019, doi: 10.2196/15429.
65. F. Z. Ahmed *et al.*, "Triage-HF Plus: a novel device-based remote monitoring pathway to identify worsening heart failure," *ESC Hear. Fail.*, vol. 7, no. 1, pp. 107–116, 2020, doi: 10.1002/ehf2.12529.
66. P. Kakria, N. K. Tripathi, and P. Kitipawang, "A real-time health monitoring system for remote cardiac patients using smartphone and wearable sensors," *Int. J. Telemed. Appl.*, vol. 2015, 2015, doi: 10.1155/2015/373474.
67. M. S. Riaz and A. Atreja, "Personalized Technologies in Chronic Gastrointestinal Disorders: Self-monitoring and Remote Sensor Technologies," *Clin Gastroenterol Hepatol*, vol. 14, no. 12, pp. 1697–1705, 2016, doi: 10.1016/j.cgh.2016.05.009.
68. X. Zheng, S. Sun, R. R. Mukkamala, R. Vatrapu, and J. Ordieres-Meré, "Accelerating health data sharing: A solution based on the internet of things and distributed ledger technologies," *J. Med. Internet Res.*, vol. 21, no. 6, 2019, doi: 10.2196/13583.

Figures

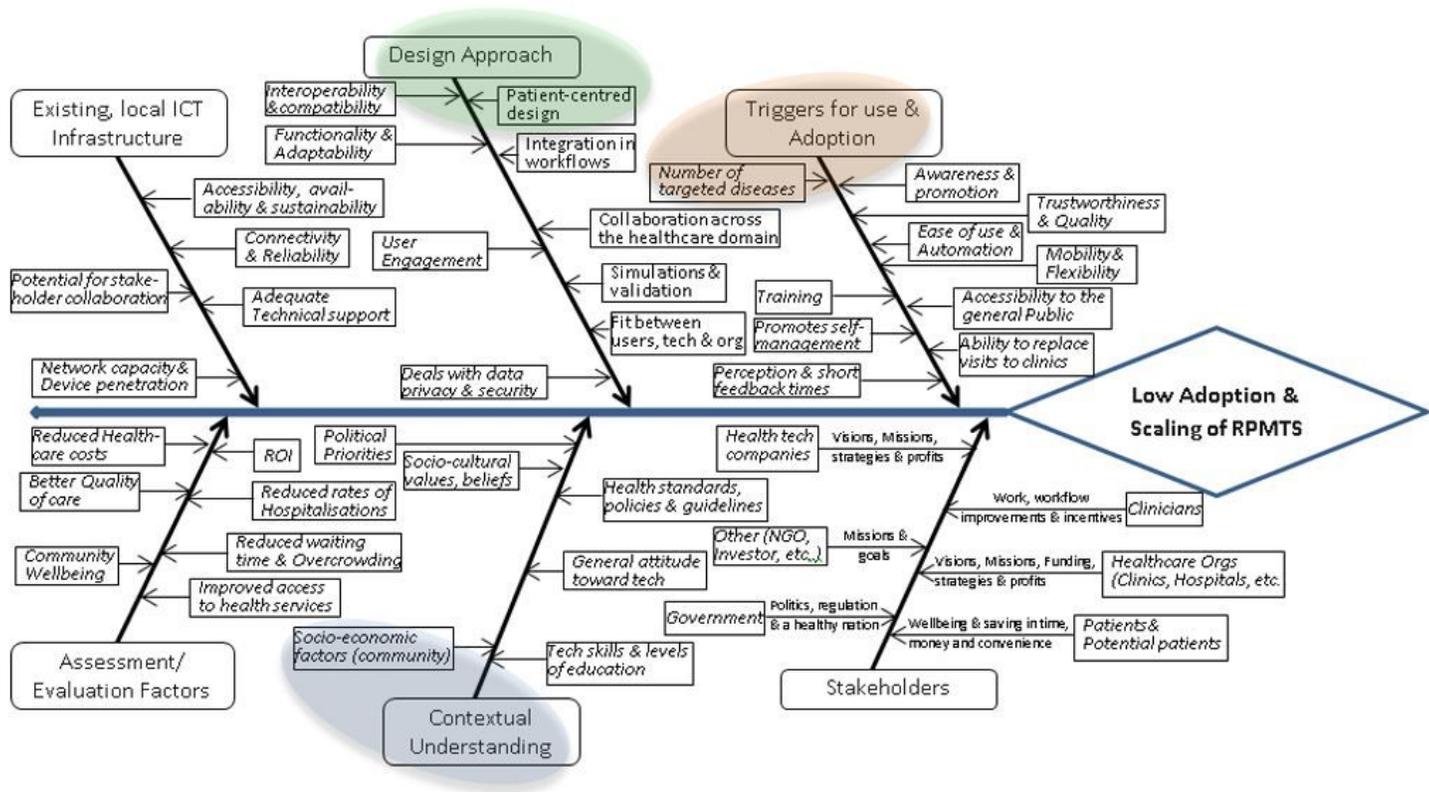


Figure 1

Cause-effect diagram for RPMTSs' low adoption and limited scope for scaling

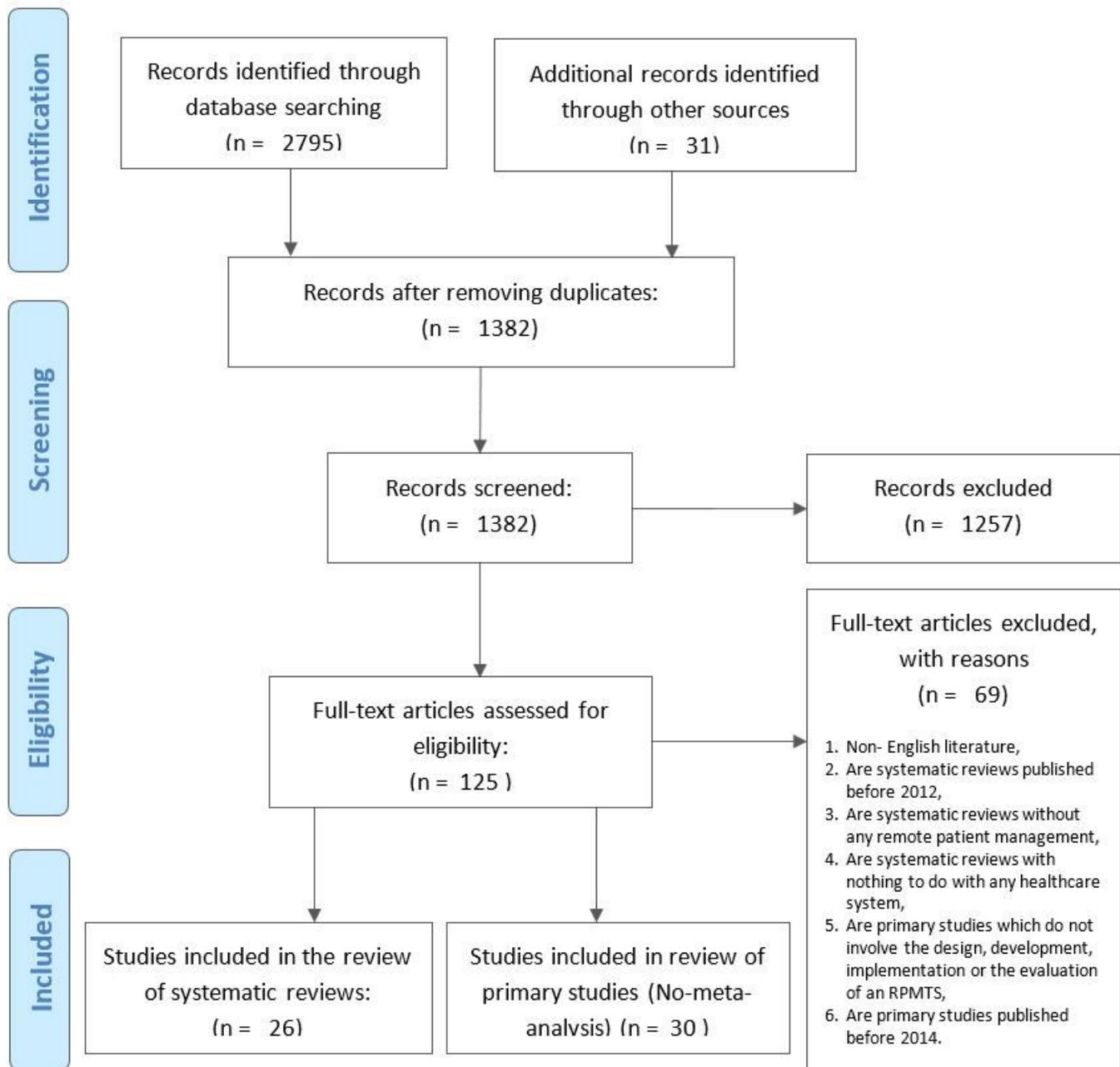


Figure 2

Article search and screening process

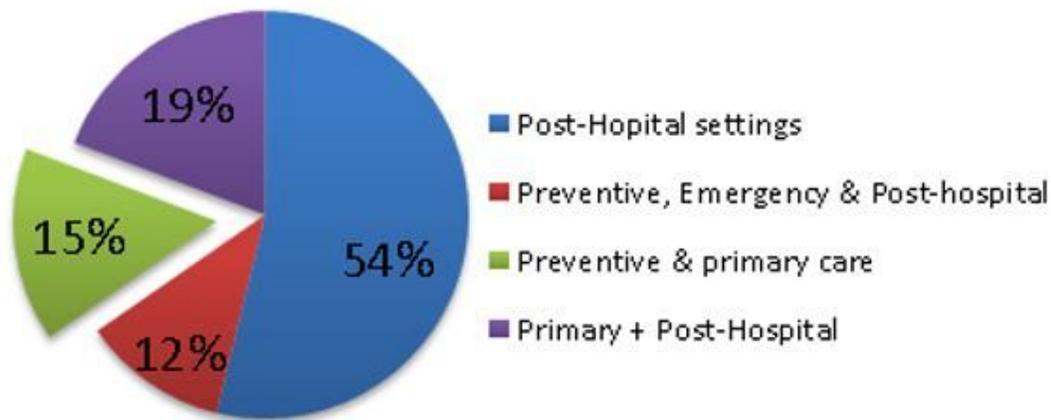


Figure 3

SR - RPMTS deployment in healthcare domain

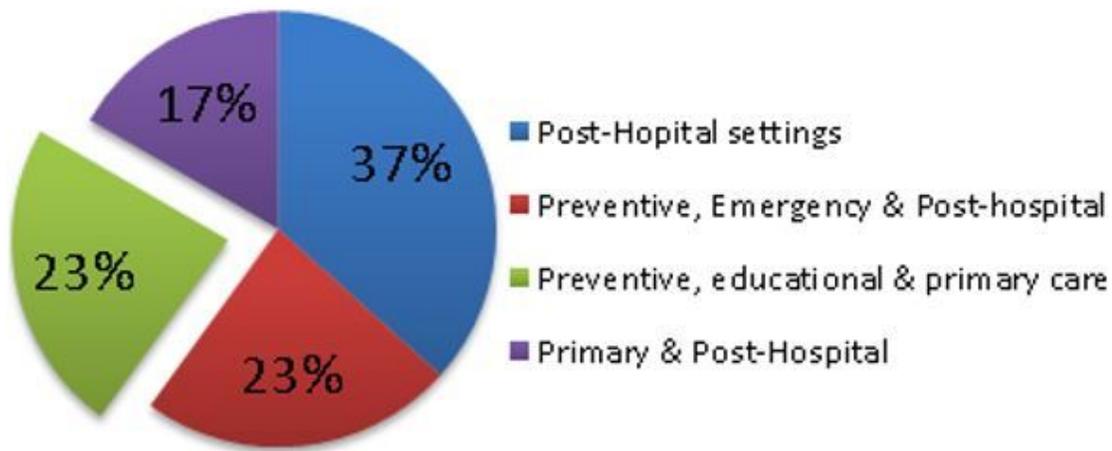


Figure 4

PA - RPMTS deployment in healthcare domain

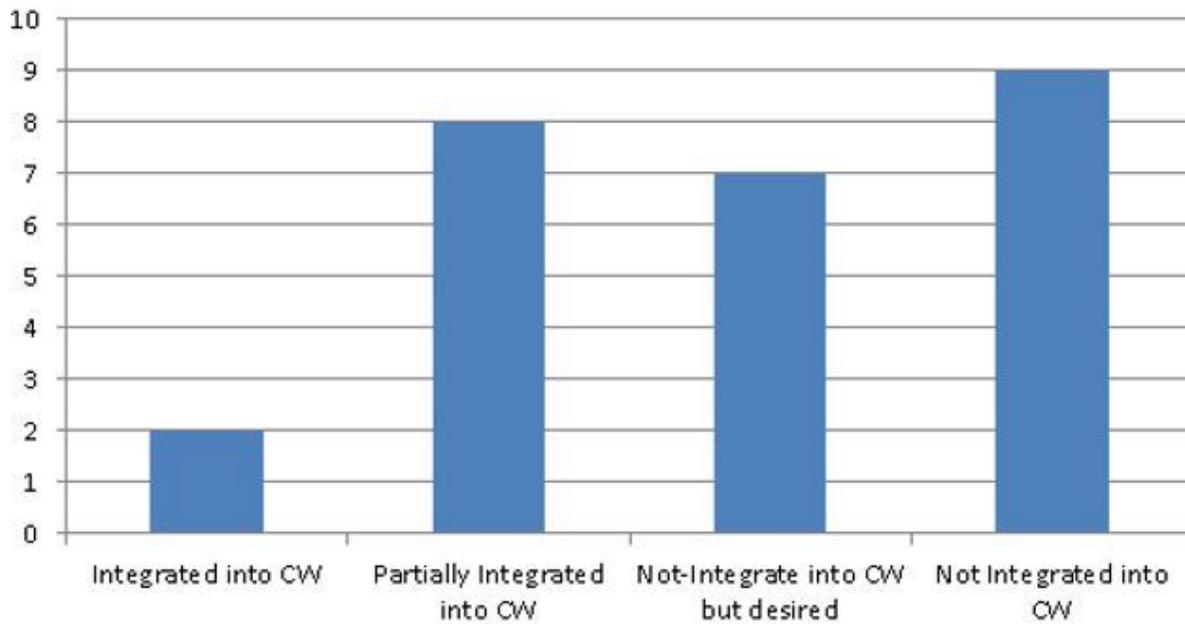


Figure 5

SR Spread of Integration into CWF

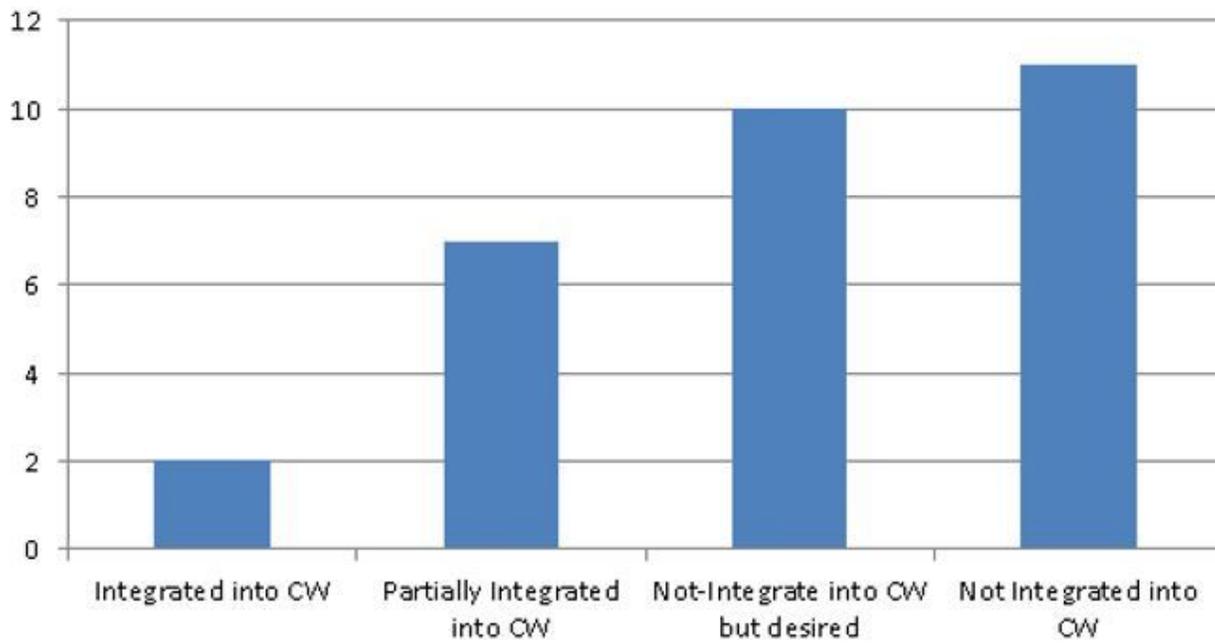


Figure 6

PA Spread of Integration into CWF

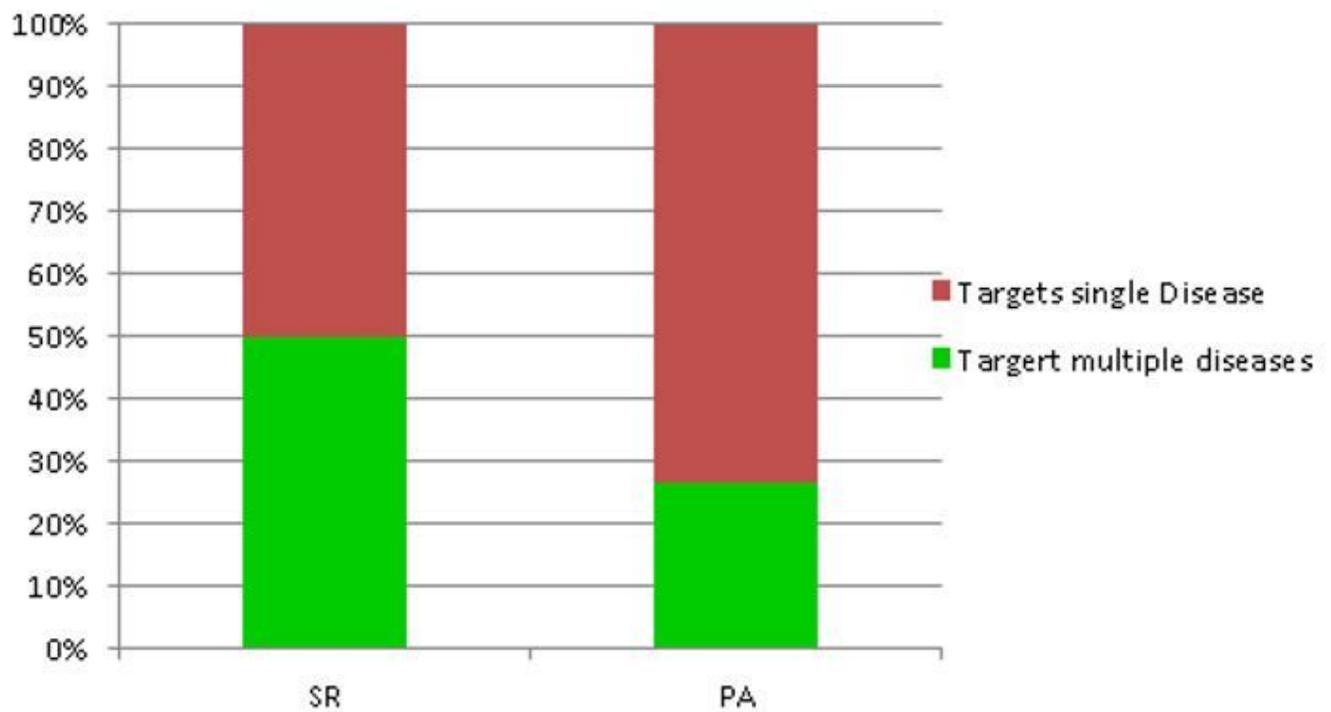


Figure 7

Comparison of targeted diseases between SR & PA

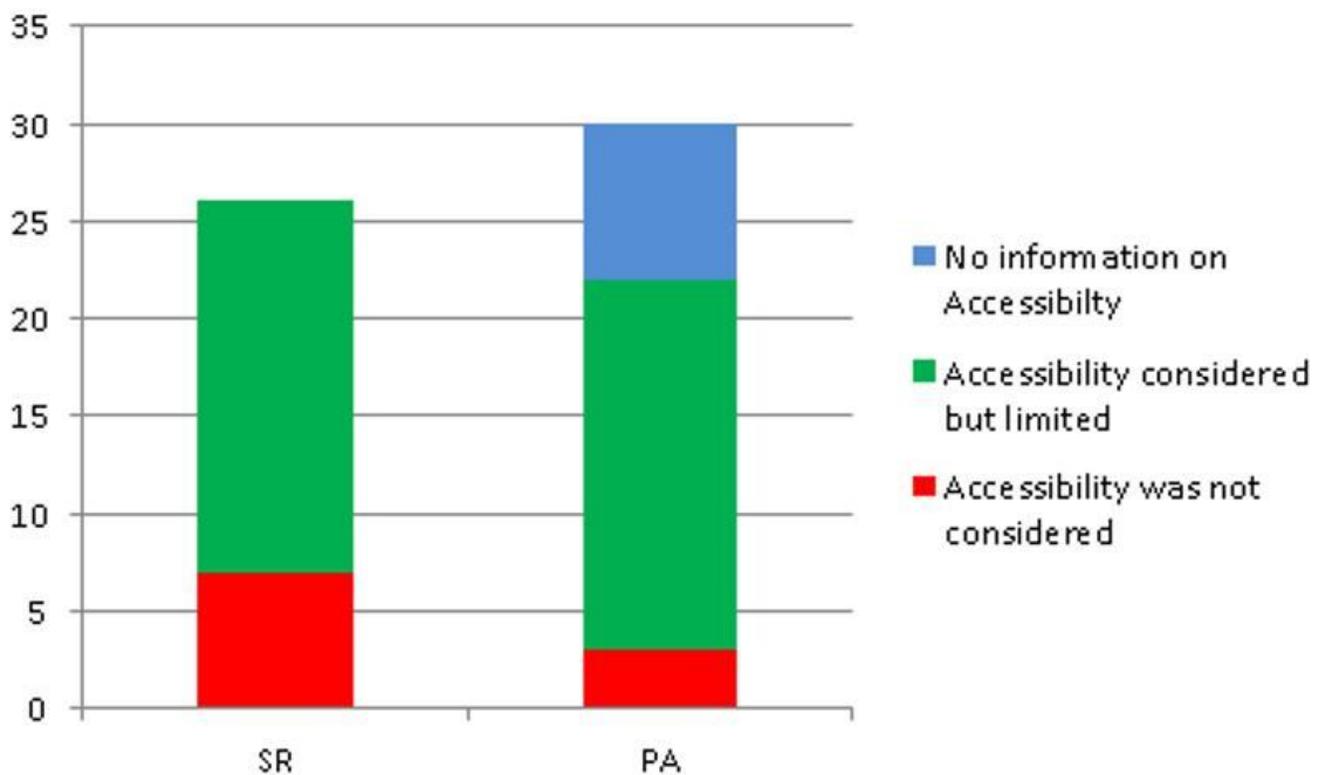


Figure 8

Levels of accessibility to the general public

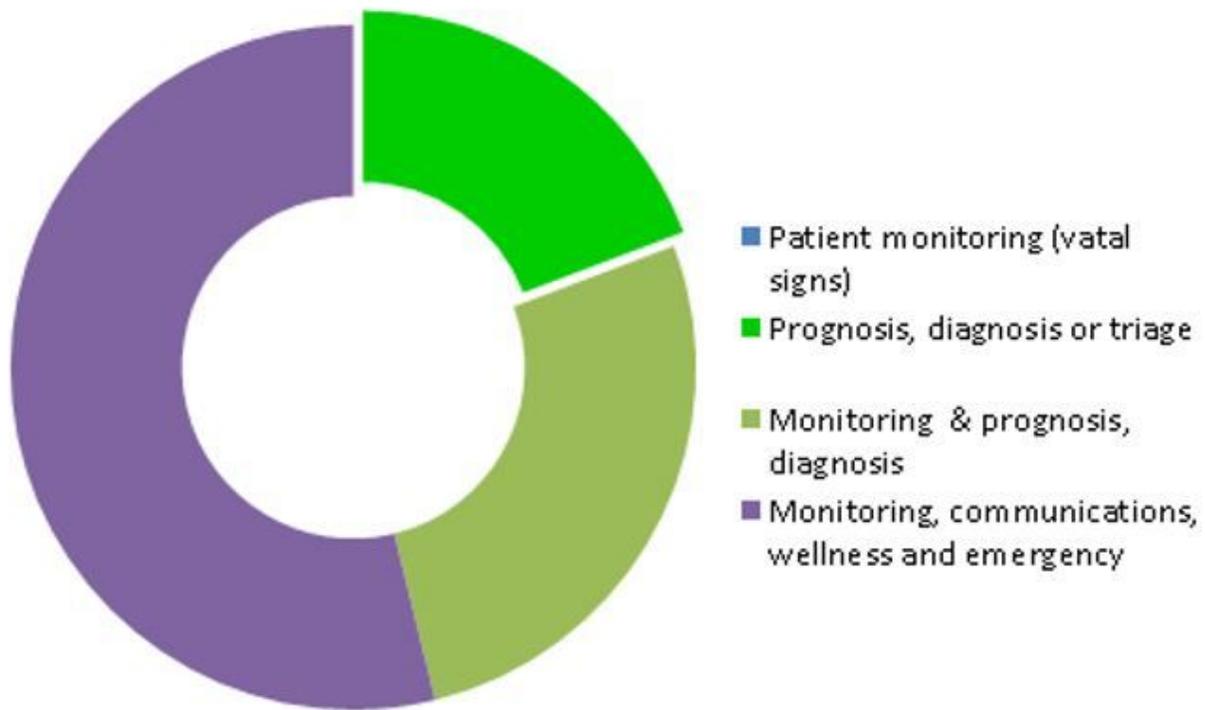


Figure 9

SR - Healthcare Organisation's main purpose

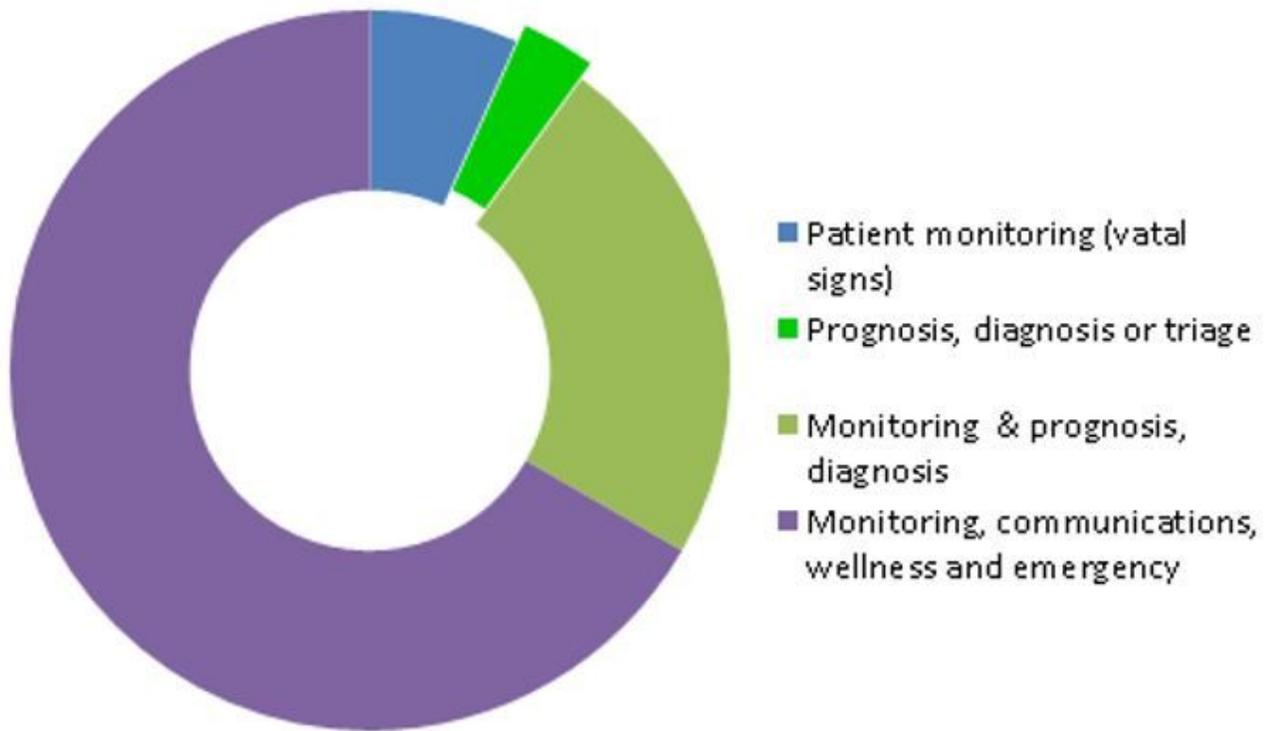


Figure 10

PA - Healthcare Organisation's main purpose

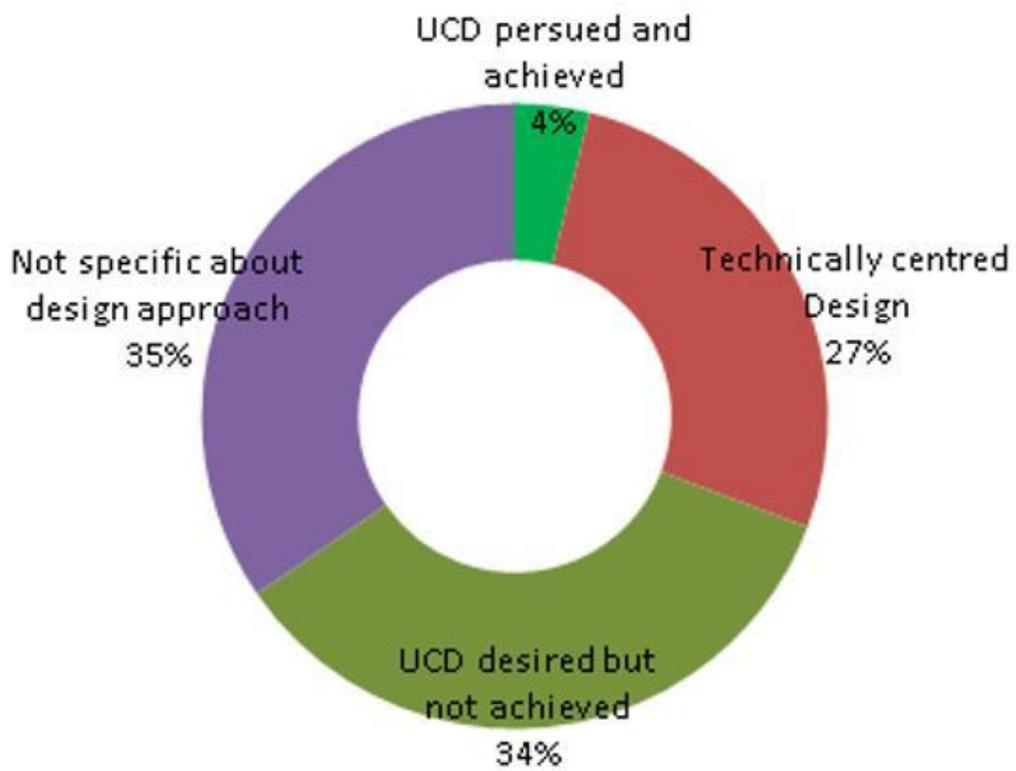


Figure 11

SR - Design approach layout

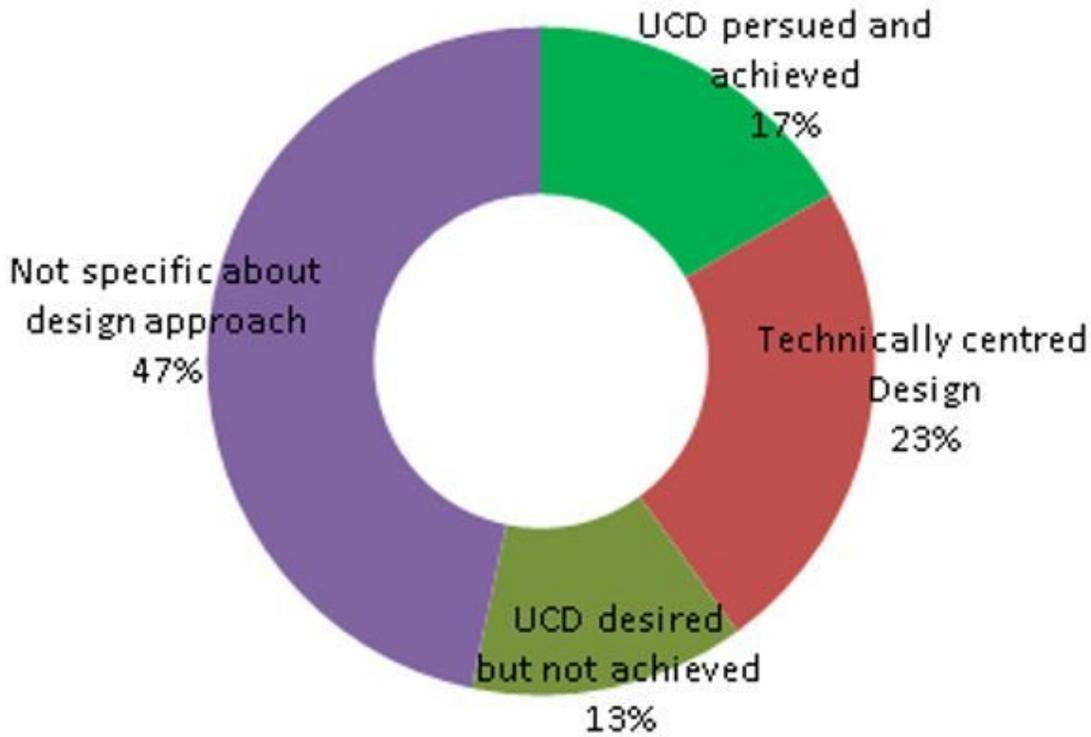


Figure 12

PA - Design approach layout

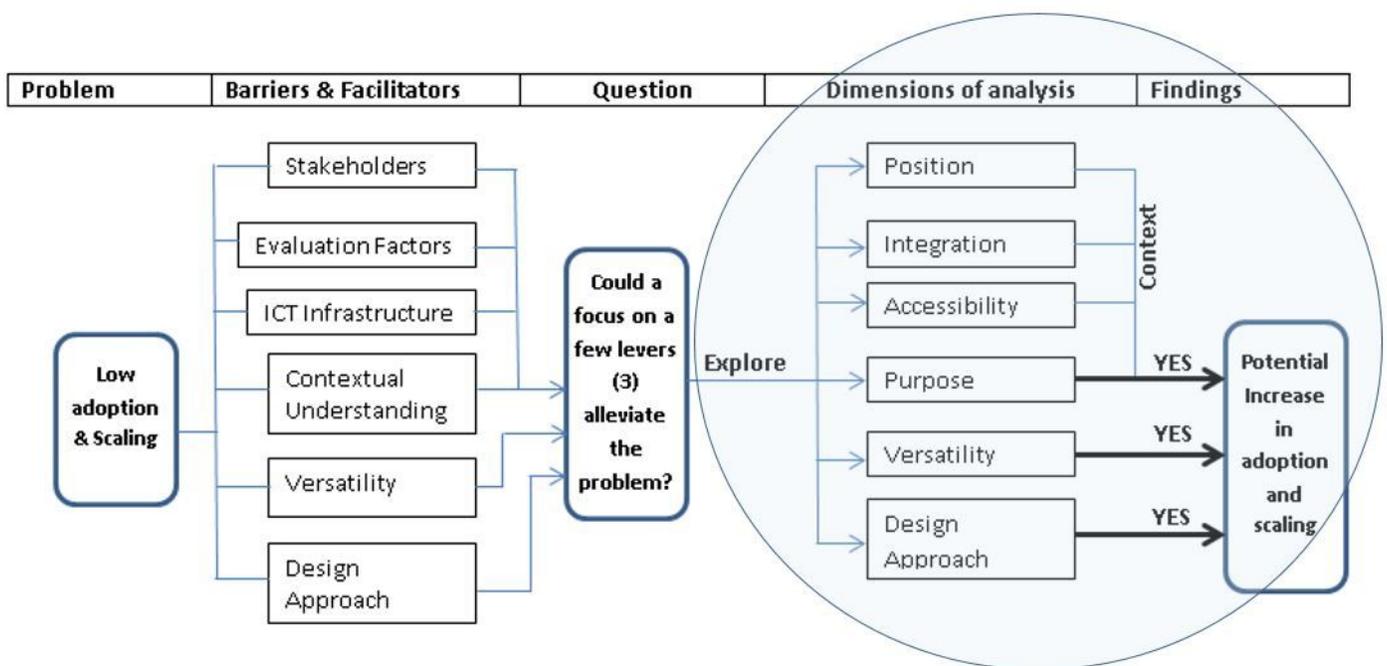


Figure 13

Summary concept map for Analysis

Supplementary Files

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- [Appendix1.docx](#)