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Upscaling of telemonitoring across geographic boundaries: a scoping review

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Abstract

Introduction and objective: Telemonitoring is strategy to digitally monitor a person's vital functions and /or physiological data at a distance using technology. Whilst pilot studies on the proposed benefits of telemonitoring show promising results, it appears challenging to implement telemonitoring on a larger scale. The aim of this scoping review is to identify the barriers and enablers for upscaling of telemonitoring across different settings and geographical boundaries in healthcare.

Methods: PubMed, EMBASE, Cinahl, Web of Science and IEEE databases were searched and outcome was assessed by two independent reviewers. Using scoping review methodology, selected studies were systematically assessed on their factors of influence on upscaling of telemonitoring.

Results: A total of 1938 titles and abstracts were screened and 19 articles were included for final analysis. This analysis revealed 89 relevant factors of influence: 18 were reported as barrier, 26 were reported as enabler and 45 factors were reported being both barrier and enabler for upscaling telemonitoring. The actual utilisation of telemonitoring varied widely across studies. The most frequently mentioned factors of influence are: resources, like costs or reimbursement; access or interface with electronic medical record and knowledge of frontline staff.

Conclusion: Successful scaling up of telemonitoring requires insight into critical success factors, especially at an overarching national level. To futureproof and facilitate upscaling of telemonitoring it is recommended to find means for reimbursement to use this type of technology in usual care, and to explore alternative payment models. A wide program on change management, national or regional coordinated, is key. Clear regulatory conditions and professional guidelines may further facilitate widespread adoption and use of telemonitoring. Future research should focus on converting the 'barriers and enablers' as identified by this review into a useful tool or guideline supporting further nationwide upscaling of telemonitoring.

Keywords: Telemonitoring, Scoping Review, Upscaling, Implementation, remote health monitoring

Article summary – strengths and limitations

- This scoping review used a transparent methodological approach supported by the application of an established methodological framework.
- Narrowing down the definition of telemonitoring in the search is an important strength of study.
- The use of Mendel's framework, which provided to be fit for categorizing the scoping review results on upscaling of telemonitoring across the included studies, is another strength of this study.
- A second reviewer encoded a purposeful sample of all extracted text components, however, no significant differences were identified between the first and second reviewer.

Introduction

Telemonitoring is the collection, transmission, evaluation, and communication of individual health data from a patient to their healthcare provider or extended care team from outside a hospital or clinical office (i.e., the patient's home) using personal health technologies including wireless devices, wearable sensors, implanted health monitors, smartphones and mobile apps.[1] Pilot studies show that telemonitoring supports self-management, for instance by offering direct feedback to the patient. Furthermore, telemonitoring improves (early) detection of disease or clinical deterioration and thereby has the potential to reduce hospitalisation and mortality.[2 3 4] In addition, telemonitoring has the potential to monitor patients more frequently. As such, telemonitoring could improve quality of care, reduce the amount of time a clinician ends up spending to manage patients and increases the frequency of monitoring without increasing workload on healthcare resources.[5-8] Devices with intelligent and reliable computing sensors in wearables, hand-held devices, (smart)phones and implants have become widely available. The World Health Organisation (WHO), the European Union (EU), national governments and other governing organisations promote use of such technology if proven to be valid, reliable and sustainable, attempting to facilitate care at a distance.[9-11] However, positive results from the aforementioned small pilot studies are difficult to replicate when telemonitoring initiatives are to be implemented on a larger scale.[12 13]

In this review, following the WHO definition, 'upscaling' of telemonitoring is defined as the expansion and replication of good practice of a telemonitoring project in more than one independent organisation or setting and across geographical boundaries.[14]

In order to facilitate larger scale implementation of telemonitoring projects using personal health technologies, evidence is needed regarding the barriers and enablers for successful implementation. A preliminary literature search conducted on January 6 2020 in PubMed, JBI Evidence Synthesis, Open Science Framework registries and the PROSPERO database identified that to that moment, no systematic reviews, meta-analyses, or scoping reviews on scaling up telemonitoring have been performed and that none were underway. (Appendix 1) . Research in the field of telemonitoring is relatively new and lacks high quality and homogeneous studies on the scaling up of telemonitoring. The purpose is to identify factors of influence on scaling up. Therefore it was decided to perform a scoping review.[15] Scoping reviews are a form of knowledge synthesis that incorporate a range of study designs in order to provide a comprehensively summary.[16]

The aim of this scoping review is to identify current barriers of and enablers for upscaling telemonitoring across different settings in a structured manner.

Methods

This scoping review was conducted in accordance with the JBI methodology guidance for scoping reviews, using the Preferred Reporting Items for Systematic Reviews and Meta-Analyses – Scoping Reviews (PRISMA-ScR) checklist, which is an extension of the PRISMA checklist.[17 18] The scoping review protocol was registered on March 29th 2021, via the Open Science Framework (https://osf.io/mpq9g/)

Patient and public involvement

Patients and/or the public were not directly involved in this study.

Eligibility criteria

Studies were eligible if they focussed on remote monitoring of patients' vital functions - such as blood pressure, pulse oximetry, temperature and heart rate - by care practitioners and /or centres, and the monitored data was transmitted digitally via (smart)phone and/or Internet. Studies had to describe the implementation or adoption of telemonitoring on a larger scale, that is; in more than one organisation, or in a larger geographical area (larger regions, province or nation-wide). There were no restrictions on publication year and study design and only full-text publications were included.

Studies were restricted to the English language. Ongoing studies, conference abstracts and posters were excluded, as were studies reporting self-monitoring by patients only, and studies that solely described the effect of telemonitoring but not the implementation or adoption.

Search strategy for Scoping Review

The preliminary search identified appropriate keywords and MeSH-terms. Subsequently, a broad search strategy for Pubmed was formulated by three reviewers (HG, NE, MS) and a medical librarian, combining the identified keywords and MeSH-terms related to telemedicine, ehealth, (tele)monitoring, implementation and upscaling. No filters were applied in the final search strategy. The complete PubMed search strategy is outlined in Appendix 2 and was adapted for the other indexed databases. HG performed the literature search of PubMed, EMBASE, Cinahl, Web of Science

and IEEE in January 2020 and updated the search on July 1st 2021. Included studies were cross-referenced to identify additional studies.

Data Extraction and Analysis

One reviewer (HG) removed duplicates and led the process of study screening and selection. Study selection was managed using the online reference manager Rayyan.[19] The search results were reviewed on two sequential levels. In the initial "title and abstract stage", the article titles and abstracts were screened according to the inclusion and exclusion criteria by two researcher (HG and TF). The lists of included studies and summaries of the collected data constructed by the two researchers were compared. Any disagreements were resolved by discussion and involvement of a third researcher (DvD). In the second "full-text stage", the remaining articles were examined to ensure that they met the inclusion criteria.

Study characteristics were systematically extracted using a structured data collection form that included the following parameters: type of telemonitoring, study location, year of publication, (research)methods, patient characteristics, and outcome measures of adoption. The charted data was verified by a second reviewer (TF or DD).

Interpretation and analysis using Mendel's framework

In addition to the extraction of study characteristics, text components from the included articles, relevant to the nationwide implementation of telemonitoring, were extracted by one of the researchers (HG). The extracted text components were uploaded into a qualitative analysis software program (MAXQDA Analytics Pro, VERBI Software, 2020), and coded to capture all relevant constructs. A second researcher encoded independently of the first researcher 25% of the articles, after which they verified their coding. If there were significant differences between the first and second researcher, the differences were discussed and the procedure repeated.

The structure of the analysis was based on Mendel's framework for Building Evidence on Dissemination and Implementation in Health Services Research[20] (appendix 3). This framework supports the understanding and assessing of relevant contextual factors and dynamics affecting the dissemination, implementation, and sustainability of interventions within communities and healthcare settings. In this scoping review, the "diffusion process" items of Mendel's framework were used to better understand and generalise the relevant contextual factors from different studies involved with (nation)wide upscaling of telemonitoring.

Results

The search retrieved 2582 records. After the removal of duplicates, 1986 titles and abstracts were screened for inclusion and exclusion. 1938 studies were excluded after title and abstract screening, leaving 48 articles for full-text screening. All numbers were used to create a flowchart (Figure 1). Additional details for the reasons of exclusion are presented in Table 1. Finally, a total of 19 articles were included for analysis, describing a variety of telemonitoring solutions.[21-38]

Characteristics of studies

The general characteristics of the included studies are presented in Table 2. Eleven out of 19 articles described a survey[21 22 25 28-30 33 34 36-38], four described focus group interviews[27 31 35 39], three articles were narrative reviews[24 26 32], and one article described the results of a workshop.[40] A total of 89 factors – barriers and/or enablers – were mentioned 202 times in 19 studies.

Scale and utilisation of telemonitoring

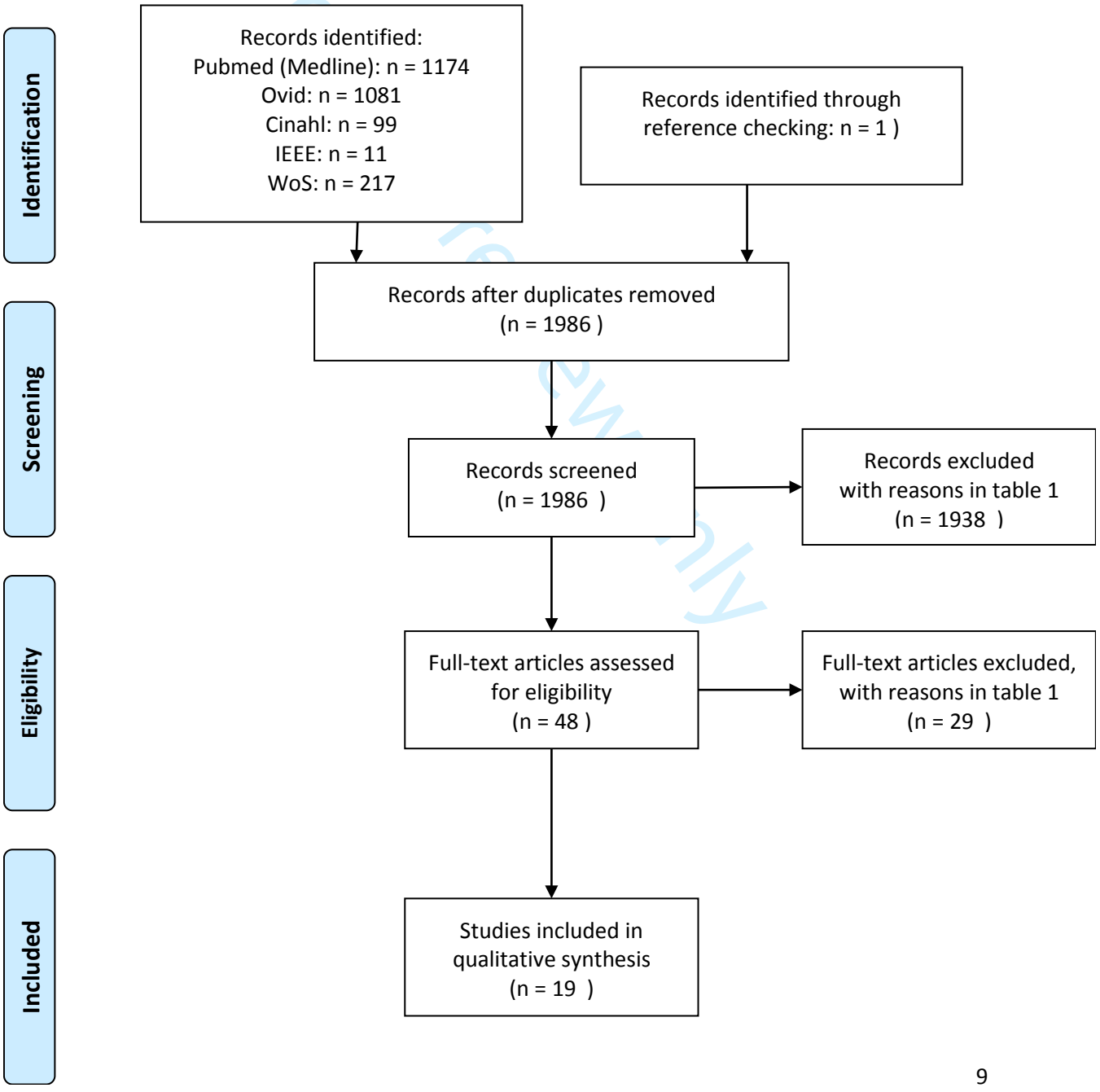
The utilisation of telemonitoring was reported in 13 of the 19 studies. Reported utilisation varied widely from "not part of routine care / not available as standard care" in Austria , Norway, Lithuania, the UK and Sweden, to "90% utilisation of tele-electrocardiography" in Brasil.[21 22 28 33 35]

There was significant heterogeneity of the definition of utilisation, which was reported as: number of patients that used telemonitoring[32 36 37 39], percentages of actual use[29], number of clinics that are engaged in telemonitoring[24 36 37], number of hospitals offering telemonitoring for high-risk pregnancies[38], number of projects in a country[30], and total recorded measurements.[37]

The percentages of the actual use of telemonitoring in patients with heart failure varied from 3% to 77%.[25 29 37] In Brasil, a telemonitoring system for the monitoring of heart rhythms with an electrocardiogram was implemented in 79 municipalities. This study showed a utilisation ratio higher than 90%. [22] In Denmark, all telemedicine projects are mapped to provide a national contemporary overview of telemedicine initiatives. Kristensen, *et al*. reported utilisation by referring to a website on which 16 active telemonitoring projects are registered within the country at this moment.[30 41] The barriers and enablers for nationwide upscaling of telemonitoring were structured in three domains using Mendel's framework: context of diffusion, stages of diffusion and intervention outcomes.

Figure 1 PRISMA flowchart showing the process of including and excluding studies.

Search syntax:
("Telemedicine"[Mesh] OR telemedicine[tiab] OR mhealth[tiab] OR m-health[tiab] OR ehealth[tiab] OR e-health[tiab] OR out-of-office[tiab])
AND
("Monitoring, Physiologic"[Mesh] OR "Monitoring, Ambulatory"[Mesh] OR monitor*[tiab] OR telemonitor*[tiab] OR health care[tiab] OR healthcare[tiab])
AND
("Implementation Science"[Mesh] OR "Health Plan Implementation"[Mesh]
AND
scale up[tiab] OR implement*[tiab] OR adoption[tiab])
AND
("Health Policy"[Mesh] OR "Policy Making"[Mesh] OR "National Health Program "[Mesh] OR policy[tiab] OR survey*[tiab] OR mapping[tiab])



What are the barriers and enablers for upscaling of telemonitoring?

Regarding the context of diffusion, the barriers and enablers retrieved were classified into six different categories of contextual factors: being a barrier, an enabler, or both according to Mendel's framework (Figure 2). Table 3 gives an overview of factors, table 4 describes barriers and/or enablers in more detail.

Number of factors that influence upscaling

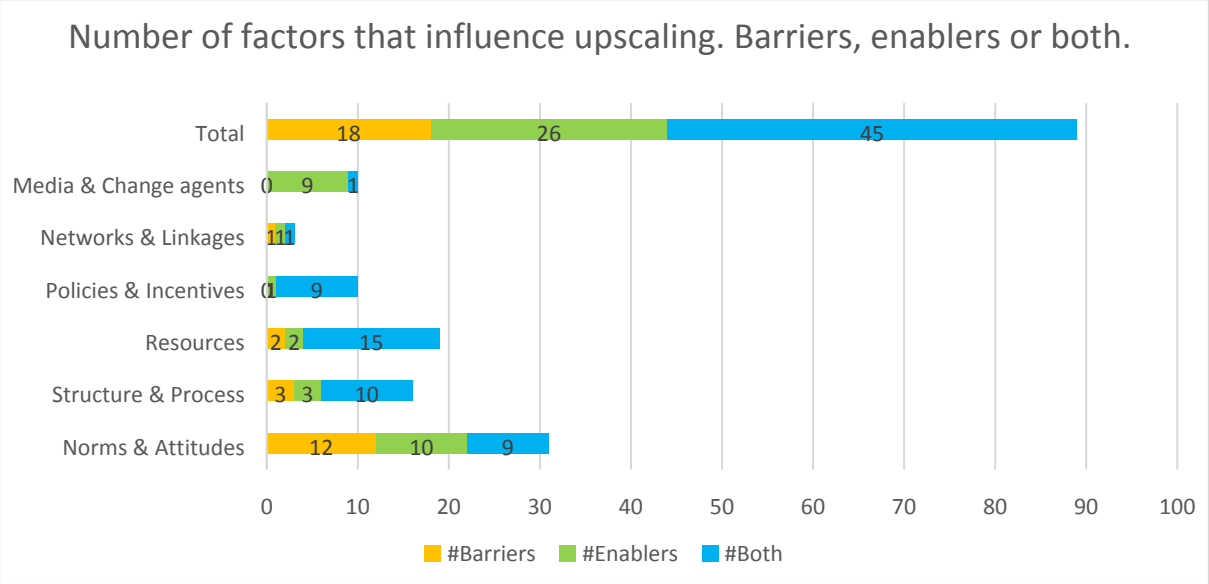


Figure 2. The number of barriers, enablers or both regarding the context of diffusion according to Mendel's framework.

1. *Norms & Attitudes.*

Primary physicians needed to adapt their standard procedures in order to make an efficient contribution to care using telemonitoring solutions, for example by using the patients' self-measurements instead of doctor's office in-house measurements.[27] A common perceived barrier of professionals is that telehealth can increase workload and make planning work more difficult when responding to monitoring alerts.[35] Across different studies professionals shared the view that patients may become too dependent on the technology making it a clear barrier for the use of telemonitoring.[27 31] Some studies report scepticism or reservations concerning telemonitoring.[21 31 35] Another important barrier for the diffusion of telemonitoring is the lack of awareness of the possibilities and opportunities for providing care using remote monitoring among both health care management and clinical staff.[40]

Healthcare professionals or centres who have such awareness generally have a more positive attitude regarding telemonitoring.[29 31 37] In two studies, healthcare professionals had high expectations of working with telemonitoring, as well as managing caseloads more efficiently.[35 36]

2. Organisational Structure & Process.

Eleven studies reported on organisational items.[21 24-28 32 35-37 40] Adoption of telemonitoring requires an infrastructural investment that will take several years to implement and will involve a complete overhaul of existing practice, clinically, financially, and managerially.[40] An elaborate program of change management is described as an enabler in the upscaling and implementation of telemonitoring.[24 40] Change management is described as continuous evaluation and assessment in the refining of patient selection criteria for remote monitoring, and personalising care pathways.[24] Security and privacy aspects influence implementation.[21 24 28 32 37] Setting up appropriate vendor agreements and protocols is described as an enabler concerning responsibility for incoming data.[21 24 28 35 36 40]

3. Resources.

Financial aspects of telemonitoring are described as an important factor in nine studies.[21 24-26 28 35-37 40] For example, Faber *et al.* described: a lack of financial resources is among the four most important barriers for the adoption of eHealth.[25] Six studies described reimbursement as a barrier for implementation of telemonitoring.[21 24 26 28 33 40] According to these studies a suitable reimbursement solution should be adopted to incentivise and engage all stakeholders and to drive the intended transformation of healthcare delivery. Along with the financial aspects, concern rises for the possible inability to access the telemonitoring system via the electronic medical records.[27 32 35 37 40] Also, a lack of interoperability generates new tasks to share telehealth data with other clinicians via electronic patient records. This also causes concerns whether the telehealth data entered in a patient's record are accurate and relevant. This makes interoperability standards crucial to the success of upscaling remote patient monitoring programs.[32 40]

4. Policies & Incentives.

Three studies indicate that policies governing telehealth may differ at the state level, which forms a barrier for implementation on interstate level.[26 35 40] On a national level, professional societies can issue guidelines to enable telemonitoring.[22 24] European and worldwide policies on innovation friendly, legal and regulatory frameworks may enable upscaling of telemonitoring.[24 26 40]

5. Networks & Linkages.

Four studies described non-profit or public-private collaborations as enablers for implementation of telemonitoring.[24 26 28 32]. Chronaki et al., for example, described a role for professional organisations like the European Society of Cardiology (ESC) in collaboration with national societies in catalysing reimbursement and adoption of telemonitoring in cardiac diseases.[24] A national repository could act as the first port of call where policy makers, clinicians, and users could access information of remote monitoring projects.[40] Another approach could be an extended partnership between device companies and health care systems involving telemonitoring services.[26]

At a regional level, collaborative efforts may connect hospital and regional health executives to network leaders, focusing on adoption, scale, and spread of network monitoring solutions. Collaboration between hospitals and primary care providers, within the Ontario Telemedicine Network, proved to be an important factor for the sustainability of a tele homecare program in Canada.[28 32]

6. Media & Change Agents.

Two studies described media and change agents as enablers for the implementation of telemonitoring. Advocates, early adopters and local champions are described as an important source of information and advice for the introduction of telemonitoring.[24 35 37]

Stages of diffusion

Barriers or enablers were reported not to be linked to an implementation stage nor to a specific stage of diffusion. However, based on the reported utilisation and phase of upscaling, it is possible to analyse what stage of diffusion a telemonitoring project is most likely to be in. Eight studies described telemonitoring in the stage of (pre)adoption. [21 25-28 33 35 36] Six studies described telemonitoring in the implementation stage. [24 31 32 37 39] Only two studies described telemonitoring (projects) in the phase of sustainment. [22 32] In three studies it was not possible to analyse the stage of diffusion.

Intervention outcomes

Barriers and enablers for implementation may affect outcomes for individuals in the community, as well as local organisations and systems of care. All the (expected) outcomes for implementation of telemonitoring are described in table 5.

Patient Care & Health Outcomes. Six studies reported outcomes on an individual level and in what way they were (expected to be) affected by telemonitoring. For example, implementation of telemonitoring was expected to improve self-care or patient empowerment. [21 24 27 28 36 40]

Organisation & System Outcomes.

Five studies reported on the (expected) outcomes on an organisational and system level. For example, when telemonitoring was implemented, it was expected that more patients can be treated (reducing admission and visits) [21 24 28 33 40], workload would be reduced [21 28 33], and costs were reduced.[21 24 28]

Discussion

This scoping review provides insight into the barriers and enablers that affect upscaling of telemonitoring in healthcare across different settings. All included studies examined large scale adoption or implementation of telemonitoring. One study described an international - European - scale up.[37] This review retrieves and identifies important overarching factors, relevant for nationwide upscaling.

One of the most frequently mentioned factors of influence is “costs” or “reimbursement”. For example; Gawalko et al. described the providing of eHealth infrastructure for free throughout the project duration to be a great enabler.[37] Chronaki et al. mentioned reimbursement as a solution: “a suitable reimbursement solution should be adopted”.[24] Diaz-Skeete et al. mentioned reimbursement as the barrier: “there is no financial backing to adopt new systems such as remote monitoring”.[40] Economic evaluations of eHealth applications are gaining momentum, and studies have shown considerable variation regarding the costs and benefits that they include.[42] Economic studies on telemonitoring in heart failure and women at risk of preeclampsia describe this duality. The initial cost of the telemonitoring equipment may be an obstacle to widespread use of telemonitoring. Although telemonitoring will require an initial financial investment, economic studies show substantially reduction of costs in the long term.[43 44] Costs, as a factor of influence, exist in coherence of “(a lack of) evidence”. In the absence of solid empirical evidence, key decision makers may doubt the effectiveness of eHealth, which, in turn, limits investment and its long-term integration into the mainstream health care system.[45] Exploring alternative payment models, for example “temporary” funding of telemonitoring by health insurers, could bridge that gap so that the necessary evidence can be collected.

Over half of the factors identified are stated both as a barrier and enabler. Therefore, factors of influence found in this scoping review can be used pragmatic; e.g. as a directive to check whether the factor is a barrier or an enabler in projects where upscaling is required. A relatively large number of factors are related to the "norms & attitudes" of users. Although this is an important factor for local implementation, one would expect that proportionately more context-related factors for nationwide scaling up would be found. Resources, attitudes, intrinsic motivation and behaviour of end-users, costs and technical knowledge of health care providers are all important factors of influence. These findings are consistent with reviews on implementation of other types of eHealth or telemedicine.[13 46-49]

The utilisation and upscaling of telemonitoring varied widely across settings and was not reported in 30% of the included studies. Because adoption is not clearly defined in the studies it is not possible to interpret the enablers and barriers for each phase of adoption. In future studies, it is recommended to give a clear definition of adoption and to report utilisation. Only then is it possible to learn more about barriers and facilitators in various stages of implementation to scale up.

Studies in this scoping review reported (expected) "patient care & health outcomes". Outcomes were not correlated to certain barriers or enablers. Based on this scoping review it's not possible to draw conclusions which factors of upscaling influence the outcomes of care, nor which outcomes of care influence the upscaling.

Practical implications

Based on the findings in this study, a coordinated and structured collaborative approach enables the upscaling of telemonitoring, embodying:

A wide program on change management, including policies and protocols on adaption of healthcare processes; Implementation coordinators, who set up requirement specifications with particular attention to interoperability standards, telemonitoring access to electronic medical records, security and privacy aspects, and appropriate vendor agreements; Widespread marketing and recruitment initiatives, for example social media channels that enable the recruitment of participating centres; Collaboration among different hospitals and between primary care and hospitals, as a way to overcome organisational and regional differences and to create an economy of scale, and;

New and innovative ways for reimbursement.

Narrowing down the definition of telemonitoring in the search is an important strength of study. A range of terms like “remote monitoring”, “teleconsultation”, “telehealth” or “telecare” is used interchangeably in the definition of telemonitoring. There are 23 different exclusion reasons for 1688 exclusions due to the terminology of telemonitoring. (Table 1). For example; teleconsultation, video-consultation and remote monitoring by telephone calls are all described as telemonitoring and 314 studies used “telemonitoring” as a keyword for a mobile health application without telemonitoring functionality. Using this precise definition of telemonitoring makes it possible to compare the results of this study with future studies on upscaling telemonitoring. Another strength of this study is the use of Mendel’s framework, which provided to be fit for categorizing the scoping review results on upscaling of telemonitoring across the included studies.

This review analysed search results from four well-known research databases. It uses key terms registered with MeSH, and multiple reviewers determined the inclusion and exclusion criteria. A limitation to this study could be the coding of extracted text components by the second reviewer, who coded only a purposeful sample of all studies. However, no significant differences were identified between the first and second reviewer, hence is therefore unlikely that this resulted in bias.

Due to the large amount of heterogeneity in the included studies with regard to study design, types of telemonitoring, and measurement of adoption or utilisation, advices on how to scale up a telemonitoring project within countries have to be made carefully. For future research it is desirable to use a clear and narrow definition of telemonitoring, utilisation and outcome measures.

Conclusion and recommendations

We live in a world where telemonitoring rapidly integrates into preventive and clinical care. Successful scaling up of telemonitoring requires insight into factors of influence in adoption, especially at an overarching national level. To futureproof and facilitate upscaling of telemonitoring it is recommended to find means for reimbursement to use this type of technology in usual care, and to explore alternative payment models early-on. A wide program on change management, national or regional coordinated, is key. Clear regulatory conditions and professional guidelines may further facilitate widespread adoption and use of telemonitoring. The results of this study can be used to help develop a guideline for upscaling.

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Contributors HG, NE, DvD and MS were involved with the design of the work. HG and TF did the screening of titles and abstracts to include studies. HG, TF and DvD extracted study characteristics. HG and DvD encode extracted text components. HG, TF, NE, DvD and MS prepared the original draft of the paper. SN, TvdB and MS contributed to the refinement of the paper. All authors have read and approved the final paper and agree to be accountable for all aspects of the work.

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Table 1 Reasons for exclusion. EHR = Electronic Health Record, mHealth = mobile Health, RFID = Radio-frequency identification, tele-ICU = tele intensive care unit, AI = artificial intelligence, AR/VR = augemented reality / virtual reality.

# excluded		Reasons
1938	1688	Not describing telemonitoring as defined in the inclusion criteria; but described 449 teleconsultation 314 mHealth applications (without telemonitoring functionality) 217 health informatics topic in general 121 implementation of an EHR 93 e-mental health 55 lifestyle promotion 43 internet based therapy 20 tele-dermatology 16 addiction related 16 tele-rehabilitation 13 e-prescription 12 tele-ICU 12 smart home (care) 10 related to systems and technology 8 teledentistry 6 AI related 5 e-registries 5 teleradiology 4 tele-ophtalmology 3 background articles 2 teleaudiology, 2 blockchain, 2 internet of things, 2 robotics, 1 RFID, 1 AR/VR 283 excluded for not describing telemonitoring with other reasons
	139	articles described a telemonitoring or eHealth project, without describing implementation or adoption.
	51	Articles described telemonitoring implementation, but not in more than one independent organisation or setting and across geographical boundaries.
	25	study protocol
	21	opinion papers or interviews
	14	non-English

Table 2 Study characteristics

#	Study and year	Country	Design	Condition	Type of telemonitoring	Analysis	Outcome measures for adoption
1	Aamodt 2019[21]	Norway and Lithuania	Cross-sectional survey	Heart failure care	Body weight, blood pressure, heart rate, dyspnea	Summative content analysis	Reported as not part of routine care / standard care
2	Alkmim 2019 [22]	Brazil	Survey	Cardiology	Tele-ECG	Descriptive statistics	Utilisation>3days per week
3	Chronaki 2013 [24]	Europe	Narrative review	Diverse	Tele-ECG	N.a.	Health care costs + number of clinics engaging in TM
4	Cook 2016 [39]	UK	Qualitative semi-structured interviews	COPD	Telehealth: Pulse oximetry, temperature, pulse, blood pressure	Framework method	N.a.
5	Diaz-Skeete[40]	Republic of Ireland	Workshop report	Cardiac care	n.a.	n.a.	n.a.
6	Faber, 2017 [25]	Netherlands	Survey	Heart failure + diabetes	N.a.	Structured equation modelling approach	Extent of adoption in percentages
7	Fraiche 2017 [26]	US	Narrative review	Heart failure	Blood pressure, weight, ECG	N.a.	N.a.
8	Hanley 2018 [27]	Scotland	Qualitative interview + focus groups	COPD, hypertension, BP after stroke, COPD, heart failure, diabetes	SpO2, BP, blood glucose,	Interpretive description approach and thematic analysis	N.a.
9	Kato 2015 [28]	Japan and Sweden	Cross-sectional survey	Heart failure	Monitoring physical condition and noticing a decline	Descriptive analysis and content analysis methodology	4 domains Reported as not part of routine care
10	Klack, 2013 [29]	Germany	Survey	Heart patient	weight, temperature, blood pressure, coagulation	Descriptive statistics	Physician and engineers perspectives Extent of adoption in percentages

11	Kristensen 2019 [30]	Denmark	Email survey	Chronic heart failure, atrial fibrillation, COPD, ADHD, Pregnant with complications, hypertension, patients with an ICD	Blood pressure, heart rhythm, body weight, heart rate, blood glucose,	Number of initiatives in interactive map online	Number of projects registered.
12	MacNeill, 2014 [31]	UK	Semi structured qualitative interviews	Chronic heart disease, COPD and diabetes	Blood pressure, weight, oxygen, blood glucose	Modified grounded theory	
13	McGillion 2018 [32]	Canada	Narrative review	Surgical population	Respiratory rate, blood pressure, heart rate, SpO2, temperature	N.a.	N.a.
14	Muigg, 2019 [33]	Austria	Cross-sectional survey	Diabetes	Blood pressure and blood glucose	Qualitative content analysis	Reported as not part of routine care
15	Okazaki, 2013 [34]	Japan and Spain	Survey	Not specified	Not specified	Causal modeling	n.a.
16	Taylor, 2014 [35]	UK	Qualitative interviews	COPD and Chronic heart failure	Not specified	Thematic analysis	n.a.
17	de Vries, 2013 [36]	Netherlands	Survey	Heart failure	Blood pressure, weight, heart frequency, ECG	Descriptive statistics	Usage
18	Van den Heuvel[38] 2020	Netherlands	Survey	Women with pregnancy complications	Cardiotocography	Descriptive statistics	Provision of telemonitoring and perspectives of respondents
19	Gawalko[37] 2021	Europe	Survey	Management of atrial fibrillation	Remote PPG or 1-lead ECG	Descriptive statistics	Centre experience and patient experience.

n.a. = not available

Table 3. An overview of factors, classified by the "diffusion process" items of Mendel's framework

	#Factors	#Described	#Barriers	#Enablers	#Both
1. Norms & Attitudes	31	51	12	10	9
2. Structure & Process	16	33	3	3	10
3. Resources	19	75	2	2	15
4. Policies & Incentives	10	23	0	1	9
5. Networks & Linkages	3	8	1	1	1
6. Media & Change agents	10	12	0	9	1
Total	**89**	**202**	**18**	**26**	**45**

The number of times factors of influence were described in total; and the number of times factors were described as barrier, enabler or both.

Table 4. Overview of factors – barriers and/or enablers – that influence nationwide upscaling of telemonitoring.

Domain	Contextual factors	Detailed description	Barrier, Enabler or Both	Number of times mentioned in publications
Context of diffusion	Norms & Attitudes	HCP think that patients become too dependent on technology[27 31 39]	Barrier	4
		HCP have scepticism or reservations about TM[28 31 35]	Barrier	3
		There must be a perceived usefulness and usability of equipment [27 31 39]	Both	3
		TM is convenient for patients [27 31 37]	Enabler	3
		HCP have a positive attitude (towards usefulness, feasibility, potential) [29 31 37]	Enabler	3
		There is concern amongst HCP that acting on the TM data provided could lead to overtreatment[27 31]	Barrier	2
		HCP consider use of TM relevant [21 28]	Enabler	2
		HCP have high expectations of working with TM[36]	Both	2
		TM makes patients anxious [27 31]	Barrier	2
		HCP think that TM can increase workload and make planning more difficult[35 36]	Barrier	2
		Make patients feel more empowered to take a pro-active approach to their health[27] or should be empowered to engage with technologies for self-management and self-care purposes[40]	Enabler	2
		HCP perceive a shift to technology making medical decisions or support in medical decision making[29 37]	Both	2
		Although the HCP had high perceptions and expectations of working with TM, these were not positively reflected in the actual experiences.[36]	Barrier	1
		HCP expect to manage caseload more efficiently[35]	Enabler	1
		Change personal practice[27]	Both	1
		Concerns about the impact of telehealth on nursing roles[35]	Barrier	1
		HCP experience a lack of advantage[28]	Barrier	1
		HCP who have the knowledge and experience in TM, tend to have a less positive attitude compared with technical professionals, who might be driven by their greater enthusiasm for technology in general.[29]	Both	1
		HCP think that TM is more expensive than conventional treatment[29]	Barrier	1
		Technical professionals are more confident about patient compliance then HCP [29]	Both	1
		HCP concern about privacy protection[29]	Barrier	1

		HCP concern about the loss of control over the medical treatment[29]	Barrier	1
		HCP think that patient acceptance is a factor of influence[37]	Both	1
		Use of telehealth is an important new skill for HCP, as was the ability to understand trends in the management of long-term conditions[31]	Enabler	1
		HCP see TM as an opportunity for professional career development[31]	Enabler	1
		HCP consider "Our centre is innovative" [21]	Enabler	1
		Patients need to accept their old age and health condition, before they use TM [39]	Both	1
		Reducing the level of face-to-face contact with the patients was a concern for professionals, but this concern was not universally shared by patients, some of whom experienced the non-face-to-face contact as additional and efficient input.[27]	Enabler	1
		HCP have concerns about the appropriateness of telehealth for the very severely ill[31]	Barrier	1
		Early positive experiences and the sharing of success were identified as key enablers for staff acceptance. Early negative experiences of telehealth have a long-lasting impact on staff acceptance and the predominant view among participants[35]	Both	1
		HCP state that telemonitoring provides higher patient satisfaction (related to home-monitoring) and does not require hospital staff to visit patients at home [38]	Enabler	1
	Organisational structure & process	Security and privacy aspects that influence implementation [21 24 28 32 38 40]	Both	6
		Rules and protocols on the implementation of the system and responsibility for incoming data[21 28 35 36 40]	Both	5
		Certain processes / coordination support implementation of TM [28 32 35 36]	Both	4
		Use of TM enables clinical decision support and influence adoption of guidelines [24 26 27]	Enabler	3
		Regular data sharing had a motivating effect on patients, as they were aware that at some point the readings may be reviewed [27] or is a possible limitation[40]	Both	2
		A wide program of change management to support healthcare transformation and adoption of new working practices [24 40]	Both	2
		Reduce admissions or readmissions [21 36]	Enabler	2
		Creating central databases making the transmitted data accessible to the treating physician and serving as data registries that benefit medical research [24]	Enabler	1
		Set up appropriate vendor agreements and infrastructure [24]	Both	1
		Protocols on the acceptable length of time between the moment of incoming patient data and the response of the HCP(response-reaction time) [36]	Both	1

		Difficult to obtain relevant data about patients and ensuring that relevant data – limited tailoring to individual patient - is shared with HCP [35]	Barrier	1
		Limited options for discharging patients who will benefit from continued use [35]	Barrier	1
		Referral routes should be opened up for patients with other conditions and with less complex needs [35]	Both	1
		A changing environment is a barrier [35]	Barrier	1
		The introduction (the way of communication, red.) to frontline staff influences implementation [35]	Both	1
		Organisational size influences implementation of TM [25]	Both	1
	Resources	Costs / financing of TM [21 24-26 28 35-38]	Both	9
		Knowledge of HCP / training of frontline staff [21 24 28 32 35-37 40]	Both	8
		Reimbursement as an element of financial resources [21 24 26 28 33 37 38 40]	Both	8
		The TM-system access to the EMR / interfacing of technologies [24 26 27 32 35 37]	Both	6
		Design of telemonitoring system / usability [26 27 32 37 39 40]	Both	6
		Availability of equipment [21 28 35 37]	Both	5
		Sufficient staffing [26 28 32 37 40]	Both	5
		Time for implementation TM [27 32 35]	Both	5
		Lack of evidence for TM [21 24 26 40]	Both	4
		Engage stakeholders in system design [32 35 40]	Both	4
		(Lack of)Cloud acces, internet access or cellular access [28 32 37]	Both	3
		Organisational readiness [25 33]	Both	2
		Significant income disparities which impact the ability to enforce guidelines and advance adoption of TM [24]	Barrier	2
		An externally resourced system for installation, technical support, maintenance and de-installation [35 37]	Both	2
		Local “champions” [35]	Both	1
		Top management support [25 40]	Both	1
		Staff to assume monitoring and management responsibilities for patients outside the hospital [26]	Both	1
		On-boarding process to a TM project. [37]	Both	1
		(Patient)education to address concerns regarding the use of remote monitoring , specifically for older adults, as an enabler [40]	Enabler	1
		Assessment of added value should be calculated [38]	Enabler	1
	Policies & Incentives	Addressing security, social and ethical issues to enable implementation of TM [24 28 32 37 38]	Both	5

		A (lack of) vision of an organisation on implementing TM [21 28 35]	Both	3
		Worldwide, European and statelevel policies and legal and regulatory frameworks [24 26 40]	Both	3
		New or adjusted workflows, care paths or data management [24 27 37]	Both	3
		Consensus statements and national guidelines [22 24]	Both	2
		Reimbursement or alternative payment models as a financial incentive for organisations [24 26]	Both	2
		Target patients, volume of population, data load and work intensity within organisations [28 35 37]	Both	3
		Interoperability standards crucial to the success of scaling remote patient monitoring programs [32]	Both	1
		Policy and practice developments affecting health care services [35]	Both	1
		Importance of TM for health authorities [21]	Enabler	1
	Networks & Linkages	Collaboration non-profit or public-private organisations [22 24 26 35 40]	Both	5
		Not being able to collaborate with other hospitals or clinics and primary care providers [28 32]	Barrier	2
		Professional organisations in collaboration with national societies can play an important role in catalysing reimbursement and adoption [24]	Enabler	1
	Media & Change Agents	Advocates, early adopters and local champions enable implementation of TM [24 35]	Enabler	2
		Create (and increase) awareness in the general clinical community of the potential that remote monitoring has [37 40]	Enabler	2
		A standardized initiation video call to inform and instruct each participating centre[37]	Enabler	1
		(Lack of) guidelines from health care authorities [21]	Both	1
		Device manufacturer that invest in TM [24]	Enabler	1
		The dynamics in the COVID-19 pandemic may have impacted the use of TM[37]	Enabler	1
		Consensus on the implementation and research agenda can pave the road to the widespread use of digital health servicies[38]	Enabler	1
		A national repository could act as the first port of call where policy makers, clinicians and users could access information on remote monitoring projects[40]	Enabler	1
		Information about strategies to educate and empower patients were provided[37]	Enabler	1
		Professional societies can review and potentially endorse TM applications that offer valuable decision support and empower the physician's relationship to the patient [24]	Enabler	1

HCP= Health Care Professional, **TM**= Telemonitoring

Table 5. The (expected) intervention outcomes when telemonitoring is implemented.

Domain	Contextual factors	Detailed description	Number of publications mentioned
Intervention outcomes	Patient care & health outcomes	(improve) self-care or patient empowerment [21 24 27 28 36 40]	6
		(improve) quality of care [21 28 33 36 40]	4
		(improve) patient education [21 28 36]	3
		(improve) symptoms of disease [28 36]	2
		(improve) quality of life [24]	1
	Organisation & System outcomes	Treat more patients (and reduce admission and visits) [21 24 28 33 36 40]	5
		(reduce) workload [21 28 33 36]	4
		(reduce) costs [21 24 28]	3
		(improve) adherence to guidelines [21 36]	2
		Contribute to continuity of care [24]	1

Appendix 1. Preliminary search

Database	Search syntax	Results
Pubmed	("Telemedicine"[Mesh] OR telemedicine[tiab] OR mhealth[tiab] OR m-health[tiab] OR ehealth[tiab] OR e-health[tiab]) AND ("Monitoring, Physiologic"[Mesh] OR "Monitoring, Ambulatory"[Mesh] OR telemonitor*[tiab]) AND ("Implementation Science"[Mesh] OR "Health Plan Implementation"[Mesh] AND scale up[tiab] OR implement*[tiab] OR adoption[tiab])	723 of which 156 meta-analysis or reviews. None relevant for upscaling telemonitoring
JBI Evidence Synthesis	Telemonitoring AND Implementation	14 results, none relevant.
Open Science framework	Telemonitoring OR telemedicine	29 registries, none about upscaling
Prospero database	(telemonitoring [all fields] OR telemedicine [MeSH]) AND Implementation Science [MeSH] OR Regional Health Planning [MeSH] OR Health Plan Implementation [MeSH] OR Implementation [all fields]	102 results, none relevant for upscaling telemonitoring.

Appendix 2. Search syntax

Search syntax:

("Telemedicine"[Mesh] OR telemedicine[tiab] OR mhealth[tiab] OR m-health[tiab] OR ehealth[tiab] OR e-health[tiab] OR out-of-office[tiab])

AND

("Monitoring, Physiologic"[Mesh] OR "Monitoring, Ambulatory"[Mesh] OR monitor*[tiab] OR telemonitor*[tiab] OR health care[tiab] OR healthcare[tiab])

AND

("Implementation Science"[Mesh] OR "Health Plan Implementation"[Mesh]

AND

scale up[tiab] OR implement*[tiab] OR adoption[tiab])

AND

("Health Policy"[Mesh] OR "Policy Making"[Mesh] OR "National Health Program "[Mesh] OR policy[tiab] OR survey*[tiab] OR mapping[tiab])

Appendix 3

Framework of dissemination in health services intervention research. From: Mendel et al 2008, Adm Policy Ment Health (2008) 35:21–37. The red lined box indicates the focus in this scoping review.

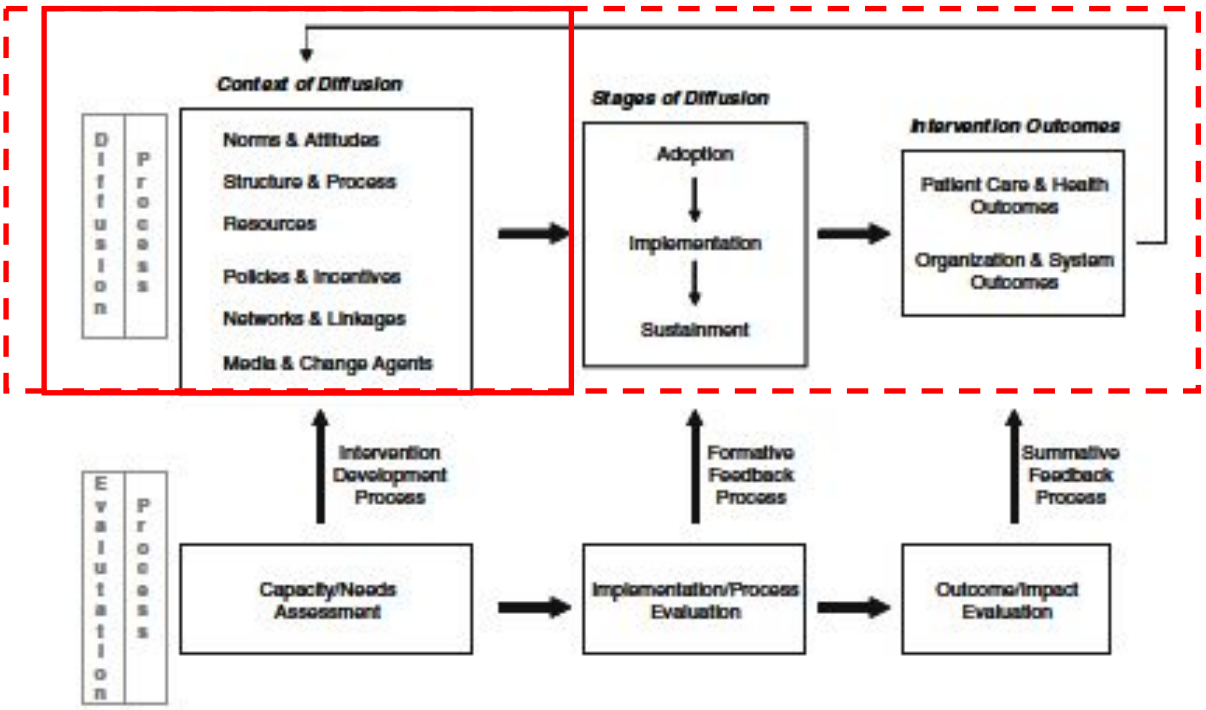


Table 1 Reasons for exclusion. EHR = Electronic Health Record, mHealth = mobile Health, RFID = Radio-frequency identification, tele-ICU = tele intensive care unit, AI = artificial intelligence, AR/VR = augemented reality / virtual reality.

# excluded		Reasons
1938	1688	Not describing telemonitoring as defined in the inclusion criteria; but described 449 teleconsultation 314 mHealth applications (without telemonitoring functionality) 217 health informatics topic in general 121 implementation of an EHR 93 e-mental health 55 lifestyle promotion 43 internet based therapy 20 tele-dermatology 16 addiction related 16 tele-rehabilitation 13 e-prescription 12 tele-ICU 12 smart home (care) 10 related to systems and technology 8 teledentistry 6 AI related 5 e-registries 5 teleradiology 4 tele-ophtalmology 3 background articles 2 teleaudiology, 2 blockchain, 2 internet of things, 2 robotics, 1 RFID, 1 AR/VR 283 excluded for not describing telemonitoring with other reasons
	139	articles described a telemonitoring or eHealth project, without describing implementation or adoption.
	51	Articles described telemonitoring implementation, but not in more than one independent organisation or setting and across geographical boundaries.
	25	study protocol
	21	opinion papers or interviews
	14	non-English

Table 2 Study characteristics

#	Study and year	Country	Design	Condition	Type of telemonitoring	Analysis	Outcome measures for adoption
1	Aamodt 2019[1]	Norway and Lithuania	Cross-sectional survey	Heart failure care	Body weight, blood pressure, heart rate, dyspnea	Summative content analysis	Reported as not part of routine care / standard care
2	Alkmim 2019 [2]	Brazil	Survey	Cardiology	Tele-ECG	Descriptive statistics	Utilisation>3days per week
3	Chronaki 2013 [3]	Europe	Narrative review	Diverse	Tele-ECG	N.a.	Health care costs + number of clinics engaging in TM
4	Cook 2016 [4]	UK	Qualitative semi-structured interviews	COPD	Telehealth: Pulse oximetry, temperature, pulse, blood pressure	Framework method	N.a.
5	Diaz-Skeete[5]	Republic of Ireland	Workshop report	Cardiac care	n.a.	n.a.	n.a.
6	Faber, 2017 [6]	Netherlands	Survey	Heart failure + diabetes	N.a.	Structured equation modelling approach	Extent of adoption in percentages
7	Fraiche 2017 [7]	US	Narrative review	Heart failure	Blood pressure, weight, ECG	N.a.	N.a.
8	Hanley 2018 [8]	Scotland	Qualitative interview + focus groups	COPD, hypertension, BP after stroke, COPD, heart failure, diabetes	SpO2, BP, blood glucose,	Interpretive description approach and thematic analysis	N.a.
9	Kato 2015 [9]	Japan and Sweden	Cross-sectional survey	Heart failure	Monitoring physical condition and noticing a decline	Descriptive analysis and content analysis methodology	4 domains Reported as not part of routine care
10	Klack, 2013 [10]	Germany	Survey	Heart patient	weight, temperature, blood pressure, coagulation	Descriptive statistics	Physician and engineers perspectives Extent of adoption in percentages

11	Kristensen 2019 [11]	Denmark	Email survey	Chronic heart failure, atrial fibrillation, COPD, ADHD, Pregnant with complications, hypertension, patients with an ICD	Blood pressure, heart rhythm, body weight, heart rate, blood glucose,	Number of initiatives in interactive map online	Number of projects registered.
12	MacNeill, 2014 [12]	UK	Semi structured qualitative interviews	Chronic heart disease, COPD and diabetes	Blood pressure, weight, oxygen, blood glucose	Modified grounded theory	
13	McGillion 2018 [13]	Canada	Narrative review	Surgical population	Respiratory rate, blood pressure, heart rate, SpO2, temperature	N.a.	N.a.
14	Muigg, 2019 [14]	Austria	Cross-sectional survey	Diabetes	Blood pressure and blood glucose	Qualitative content analysis	Reported as not part of routine care
15	Okazaki, 2013 [15]	Japan and Spain	Survey	Not specified	Not specified	Causal modeling	n.a.
16	Taylor, 2014 [16]	UK	Qualitative interviews	COPD and Chronic heart failure	Not specified	Thematic analysis	n.a.
17	de Vries, 2013 [17]	Netherlands	Survey	Heart failure	Blood pressure, weight, heart frequency, ECG	Descriptive statistics	Usage
18	Van den Heuvel[18] 2020	Netherlands	Survey	Women with pregnancy complications	Cardiotocography	Descriptive statistics	Provision of telemonitoring and perspectives of respondents
19	Gawalko[19] 2021	Europe	Survey	Management of atrial fibrillation	Remote PPG or 1-lead ECG	Descriptive statistics	Centre experience and patient experience.

n.a. = not available

Table 3. An overview of factors, classified by the "diffusion process" items of Mendel's framework

	#Factors	#Described	#Barriers	#Enablers	#Both
1. Norms & Attitudes	31	51	12	10	9
2. Structure & Process	16	33	3	3	10
3. Resources	19	75	2	2	15
4. Policies & Incentives	10	23	0	1	9
5. Networks & Linkages	3	8	1	1	1
6. Media & Change agents	10	12	0	9	1
Total	**89**	**202**	**18**	**26**	**45**

The number of times factors of influence were described in total; and the number of times factors were described as barrier, enabler or both.

Table 4. Overview of factors – barriers and/or enablers – that influence nationwide upscaling of telemonitoring.

Domain	Contextual factors	Detailed description	Barrier, Enabler or Both	Number of times mentioned in publications
Context of diffusion	Norms & Attitudes	HCP think that patients become too dependent on technology[4 8 12]	Barrier	4
		HCP have scepticism or reservations about TM[9 12 16]	Barrier	3
		There must be a perceived usefulness and usability of equipment [4 8 12]	Both	3
		TM is convenient for patients [8 12 19]	Enabler	3
		HCP have a positive attitude (towards usefulness, feasibility, potential) [10 12 19]	Enabler	3
		There is concern amongst HCP that acting on the TM data provided could lead to overtreatment[8 12]	Barrier	2
		HCP consider use of TM relevant [1 9]	Enabler	2
		HCP have high expectations of working with TM[17]	Both	2
		TM makes patients anxious [8 12]	Barrier	2
		HCP think that TM can increase workload and make planning more difficult[16 17]	Barrier	2
		Make patients feel more empowered to take a pro-active approach to their health[8] or should be empowered to engage with technologies for self-management and self-care purposes[5]	Enabler	2
		HCP perceive a shift to technology making medical decisions or support in medical decision making[10 19]	Both	2
		Although the HCP had high perceptions and expectations of working with TM, these were not positively reflected in the actual experiences.[17]	Barrier	1
		HCP expect to manage caseload more efficiently[16]	Enabler	1
		Change personal practice[8]	Both	1
		Concerns about the impact of telehealth on nursing roles[16]	Barrier	1
		HCP experience a lack of advantage[9]	Barrier	1
		HCP who have the knowledge and experience in TM, tend to have a less positive attitude compared with technical professionals, who might be driven by their greater enthusiasm for technology in general.[10]	Both	1
		HCP think that TM is more expensive than conventional treatment[10]	Barrier	1
		Technical professionals are more confident about patient compliance then HCP [10]	Both	1
		HCP concern about privacy protection[10]	Barrier	1

		HCP concern about the loss of control over the medical treatment[10]	Barrier	1
		HCP think that patient acceptance is a factor of influence[19]	Both	1
		Use of telehealth is an important new skill for HCP, as was the ability to understand trends in the management of long-term conditions[12]	Enabler	1
		HCP see TM as an opportunity for professional career development[12]	Enabler	1
		HCP consider "Our centre is innovative" [1]	Enabler	1
		Patients need to accept their old age and health condition, before they use TM [4]	Both	1
		Reducing the level of face-to-face contact with the patients was a concern for professionals, but this concern was not universally shared by patients, some of whom experienced the non-face-to-face contact as additional and efficient input.[8]	Enabler	1
		HCP have concerns about the appropriateness of telehealth for the very severely ill[12]	Barrier	1
		Early positive experiences and the sharing of success were identified as key enablers for staff acceptance. Early negative experiences of telehealth have a long-lasting impact on staff acceptance and the predominant view among participants[16]	Both	1
		HCP state that telemonitoring provides higher patient satisfaction (related to home-monitoring) and does not require hospital staff to visit patients at home [18]	Enabler	1
	Organisational structure & process	Security and privacy aspects that influence implementation [1 3 5 9 13 18]	Both	6
		Rules and protocols on the implementation of the system and responsibility for incoming data[1 5 9 16 17]	Both	5
		Certain processes / coordination support implementation of TM [9 13 16 17]	Both	4
		Use of TM enables clinical decision support and influence adoption of guidelines [3 7 8]	Enabler	3
		Regular data sharing had a motivating effect on patients, as they were aware that at some point the readings may be reviewed [8] or is a possible limitation[5]	Both	2
		A wide program of change management to support healthcare transformation and adoption of new working practices [3 5]	Both	2
		Reduce admissions or readmissions [1 17]	Enabler	2
		Creating central databases making the transmitted data accessible to the treating physician and serving as data registries that benefit medical research [3]	Enabler	1
		Set up appropriate vendor agreements and infrastructure [3]	Both	1
		Protocols on the acceptable length of time between the moment of incoming patient data and the response of the HCP(response-reaction time) [17]	Both	1

		Difficult to obtain relevant data about patients and ensuring that relevant data – limited tailoring to individual patient - is shared with HCP [16]	Barrier	1
		Limited options for discharging patients who will benefit from continued use [16]	Barrier	1
		Referral routes should be opened up for patients with other conditions and with less complex needs [16]	Both	1
		A changing environment is a barrier [16]	Barrier	1
		The introduction (the way of communication, red.) to frontline staff influences implementation [16]	Both	1
		Organisational size influences implementation of TM [6]	Both	1
	Resources	Costs / financing of TM [1 3 6 7 9 16-19]	Both	9
		Knowledge of HCP / training of frontline staff [1 3 5 9 13 16 17 19]	Both	8
		Reimbursement as an element of financial resources [1 3 5 7 9 14 18 19]	Both	8
		The TM-system access to the EMR / interfacing of technologies [3 7 8 13 16 19]	Both	6
		Design of telemonitoring system / usability [4 5 7 8 13 19]	Both	6
		Availability of equipment [1 9 16 19]	Both	5
		Sufficient staffing [5 7 9 13 19]	Both	5
		Time for implementation TM [8 13 16]	Both	5
		Lack of evidence for TM [1 3 5 7]	Both	4
		Engage stakeholders in system design [5 13 16]	Both	4
		(Lack of)Cloud acces, internet access or cellular access [9 13 19]	Both	3
		Organisational readiness [6 14]	Both	2
		Significant income disparities which impact the ability to enforce guidelines and advance adoption of TM [3]	Barrier	2
		An externally resourced system for installation, technical support, maintenance and de-installation [16 19]	Both	2
		Local “champions” [16]	Both	1
		Top management support [5 6]	Both	1
		Staff to assume monitoring and management responsibilities for patients outside the hospital [7]	Both	1
		On-boarding process to a TM project. [19]	Both	1
		(Patient)education to address concerns regarding the use of remote monitoring , specifically for older adults, as an enabler [5]	Enabler	1
		Assessment of added value should be calculated [18]	Enabler	1
	Policies & Incentives	Addressing security, social and ethical issues to enable implementation of TM [3 9 13 18 19]	Both	5

		A (lack of) vision of an organisation on implementing TM [1 9 16]	Both	3
		Worldwide, European and statelevel policies and legal and regulatory frameworks [3 5 7]	Both	3
		New or adjusted workflows, care paths or data management [3 8 19]	Both	3
		Consensus statements and national guidelines [2 3]	Both	2
		Reimbursement or alternative payment models as a financial incentive for organisations [3 7]	Both	2
		Target patients, volume of population, data load and work intensity within organisations [9 16 19]	Both	3
		Interoperability standards crucial to the success of scaling remote patient monitoring programs [13]	Both	1
		Policy and practice developments affecting health care services [16]	Both	1
		Importance of TM for health authorities [1]	Enabler	1
	Networks & Linkages	Collaboration non-profit or public-private organisations [2 3 5 7 16]	Both	5
		Not being able to collaborate with other hospitals or clinics and primary care providers [9 13]	Barrier	2
		Professional organisations in collaboration with national societies can play an important role in catalysing reimbursement and adoption [3]	Enabler	1
	Media & Change Agents	Advocates, early adopters and local champions enable implementation of TM [3 16]	Enabler	2
		Create (and increase) awareness in the general clinical community of the potential that remote monitoring has [5 19]	Enabler	2
		A standardized initiation video call to inform and instruct each participating centre[19]	Enabler	1
		(Lack of) guidelines from health care authorities [1]	Both	1
		Device manufacturer that invest in TM [3]	Enabler	1
		The dynamics in the COVID-19 pandemic may have impacted the use of TM[19]	Enabler	1
		Consensus on the implementation and research agenda can pave the road to the widespread use of digital health servicies[18]	Enabler	1
		A national repository could act as the first port of call where policy makers, clinicians and users could access information on remote monitoring projects[5]	Enabler	1
		Information about strategies to educate and empower patients were provided[19]	Enabler	1
		Professional societies can review and potentially endorse TM applications that offer valuable decision support and empower the physician's relationship to the patient [3]	Enabler	1

HCP= Health Care Professional, **TM**= Telemonitoring

Table 5. The (expected) intervention outcomes when telemonitoring is implemented.

Domain	Contextual factors	Detailed description	Number of publications mentioned
Intervention outcomes	Patient care & health outcomes	(improve) self-care or patient empowerment [1 3 5 8 9 17]	6
		(improve) quality of care [1 5 9 14 17]	4
		(improve) patient education [1 9 17]	3
		(improve) symptoms of disease [9 17]	2
		(improve) quality of life [3]	1
	Organisation & System outcomes	Treat more patients (and reduce admission and visits) [1 3 5 9 14 17]	5
		(reduce) workload [1 9 14 17]	4
		(reduce) costs [1 3 9]	3
		(improve) adherence to guidelines [1 17]	2
		Contribute to continuity of care [3]	1

Appendix 1. Preliminary search

Database	Search syntax	Results
Pubmed	("Telemedicine"[Mesh] OR telemedicine[tiab] OR mhealth[tiab] OR m-health[tiab] OR ehealth[tiab] OR e-health[tiab]) AND ("Monitoring, Physiologic"[Mesh] OR "Monitoring, Ambulatory"[Mesh] OR telemonitor*[tiab]) AND ("Implementation Science"[Mesh] OR "Health Plan Implementation"[Mesh] AND scale up[tiab] OR implement*[tiab] OR adoption[tiab])	723 of which 156 meta-analysis or reviews. None relevant for upscaling telemonitoring
JBI Evidence Synthesis	Telemonitoring AND Implementation	14 results, none relevant.
Open Science framework	Telemonitoring OR telemedicine	29 registries, none about upscaling
Prospero database	(telemonitoring [all fields] OR telemedicine [MeSH]) AND Implementation Science [MeSH] OR Regional Health Planning [MeSH] OR Health Plan Implementation [MeSH] OR Implementation [all fields]	102 results, none relevant for upscaling telemonitoring.

Appendix 2. Search syntax

Search syntax:

("Telemedicine"[Mesh] OR telemedicine[tiab] OR mhealth[tiab] OR m-health[tiab] OR ehealth[tiab] OR e-health[tiab] OR out-of-office[tiab])

AND

("Monitoring, Physiologic"[Mesh] OR "Monitoring, Ambulatory"[Mesh] OR monitor*[tiab] OR telemonitor*[tiab] OR health care[tiab] OR healthcare[tiab])

AND

("Implementation Science"[Mesh] OR "Health Plan Implementation"[Mesh]

AND

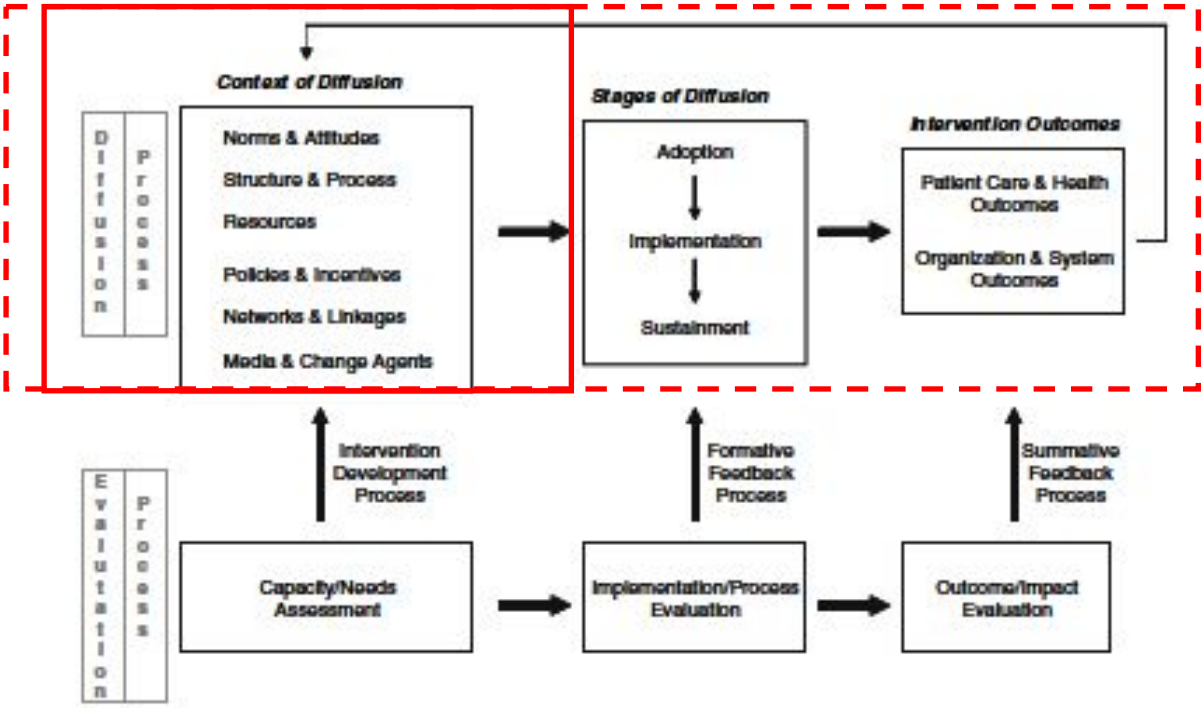
scale up[tiab] OR implement*[tiab] OR adoption[tiab])

AND

("Health Policy"[Mesh] OR "Policy Making"[Mesh] OR "National Health Program "[Mesh] OR policy[tiab] OR survey*[tiab] OR mapping[tiab])

Appendix 3

Framework of dissemination in health services intervention research. From: Mendel et al 2008, Adm Policy Ment Health (2008) 35:21–37. The red lined box indicates the focus in this scoping review.



PRISMA 2009 Checklist

Section/topic	#	Checklist item	Reported on page #
TITLE			
Title	1	Identify the report as a systematic review, meta-analysis, or both.	1
ABSTRACT			
Structured summary	2	Provide a structured summary including, as applicable: background; objectives; data sources; study eligibility criteria, participants, and interventions; study appraisal and synthesis methods; results; limitations; conclusions and implications of key findings; systematic review registration number.	2
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of what is already known.	4
Objectives	4	Provide an explicit statement of questions being addressed with reference to participants, interventions, comparisons, outcomes, and study design (PICOS).	4
METHODS			
Protocol and registration	5	Indicate if a review protocol exists, if and where it can be accessed (e.g., Web address), and, if available, provide registration information including registration number.	5
Eligibility criteria	6	Specify study characteristics (e.g., PICOS, length of follow-up) and report characteristics (e.g., years considered, language, publication status) used as criteria for eligibility, giving rationale.	5
Information sources	7	Describe all information sources (e.g., databases with dates of coverage, contact with study authors to identify additional studies) in the search and date last searched.	5
Search	8	Present full electronic search strategy for at least one database, including any limits used, such that it could be repeated.	Appendix 1 and Appendix 2
Study selection	9	State the process for selecting studies (i.e., screening, eligibility, included in systematic review, and, if applicable, included in the meta-analysis).	6
Data collection process	10	Describe method of data extraction from reports (e.g., piloted forms, independently, in duplicate) and any processes for obtaining and confirming data from investigators.	6
Data items	11	List and define all variables for which data were sought (e.g., PICOS, funding sources) and any assumptions and simplifications made.	6
Risk of bias in individual studies	12	Describe methods used for assessing risk of bias of individual studies (including specification of whether this was done at the study or outcome level), and how this information is to be used in any data synthesis.	N/A
Summary measures	13	State the principal summary measures (e.g., risk ratio, difference in means).	6

PRISMA 2009 Checklist

Synthesis of results	14	Describe the methods of handling data and combining results of studies, if done, including measures of consistency (e.g., I^2) for each meta-analysis.	6

Section/topic	#	Checklist item	Reported on page #
Risk of bias across studies	15	Specify any assessment of risk of bias that may affect the cumulative evidence (e.g., publication bias, selective reporting within studies).	N/A
Additional analyses	16	Describe methods of additional analyses (e.g., sensitivity or subgroup analyses, meta-regression), if done, indicating which were pre-specified.	N/A
RESULTS			
Study selection	17	Give numbers of studies screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally with a flow diagram.	7
Study characteristics	18	For each study, present characteristics for which data were extracted (e.g., study size, PICOS, follow-up period) and provide the citations.	7 & table 2
Risk of bias within studies	19	Present data on risk of bias of each study and, if available, any outcome level assessment (see item 12).	N/A
Results of individual studies	20	For all outcomes considered (benefits or harms), present, for each study: (a) simple summary data for each intervention group (b) effect estimates and confidence intervals, ideally with a forest plot.	N/A
Synthesis of results	21	Present results of each meta-analysis done, including confidence intervals and measures of consistency.	9 & Figure 2
Risk of bias across studies	22	Present results of any assessment of risk of bias across studies (see Item 15).	N/A
Additional analysis	23	Give results of additional analyses, if done (e.g., sensitivity or subgroup analyses, meta-regression [see Item 16]).	9, 10, 11, 12, Table 3, Table 4, Table 5
DISCUSSION			
Summary of evidence	24	Summarize the main findings including the strength of evidence for each main outcome; consider their relevance to key groups (e.g., healthcare providers, users, and policy makers).	12, 13
Limitations	25	Discuss limitations at study and outcome level (e.g., risk of bias), and at review-level (e.g., incomplete retrieval of identified research, reporting bias).	14
Conclusions	26	Provide a general interpretation of the results in the context of other evidence, and implications for future research.	14
FUNDING			

PRISMA 2009 Checklist

Funding	27	Describe sources of funding for the systematic review and other support (e.g., supply of data); role of funders for the systematic review.	15

From: Moher D, Liberati A, Tetzlaff J, Altman DG, The PRISMA Group (2009). Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The PRISMA Statement. PLoS Med 6(6): e1000097. doi:10.1371/journal.pmed1000097

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Enablers and barriers in upscaling telemonitoring across geographic boundaries: a scoping review

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Enablers and barriers in upscaling telemonitoring across geographic boundaries: a scoping review

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Abstract

Introduction and objective: Telemonitoring is a method to monitor a person's vital functions via their physiological data at distance, using technology. Whilst pilot studies on the proposed benefits of telemonitoring show promising results, it appears challenging to implement telemonitoring on a larger scale. The aim of this scoping review is to identify the enablers and barriers for upscaling of telemonitoring across different settings and geographical boundaries in healthcare.

Methods: PubMed, EMBASE, Cinahl, Web of Science, ProQuest and IEEE databases were searched. Resulting outcomes were assessed by two independent reviewers. Studies were considered eligible if they focused on remote monitoring of patients' vital functions and data was transmitted digitally. Using scoping review methodology, selected studies were systematically assessed on their factors of influence on upscaling of telemonitoring.

Results: A total of 2298 titles and abstracts were screened and 19 articles were included for final analysis. This analysis revealed 89 relevant factors of influence: 26 were reported as enabler, 18 were reported as barrier and 45 factors were reported being both. The actual utilisation of telemonitoring varied widely across studies. The most frequently mentioned factors of influence are: resources such as costs or reimbursement, access or interface with electronic medical record and knowledge of frontline staff.

Conclusion: Successful upscaling of telemonitoring requires insight into its critical success factors, especially at an overarching national level. To futureproof and facilitate upscaling of telemonitoring it is recommended to use this type of technology in usual care and to find means for reimbursement early on. A wide program on change management, nationally or regionally coordinated, is key. Clear regulatory conditions and professional guidelines may further facilitate widespread adoption and use of telemonitoring. Future research should focus on converting the 'enablers and barriers' as identified by this review into a guideline supporting further nationwide upscaling of telemonitoring.

Keywords: telemonitoring, scoping review, upscaling, implementation, remote health monitoring, digital health, technology, e-health

Article summary – strengths and limitations

- This scoping review uses a transparent methodological approach supported by the application of an established methodological framework.
- Narrowing down the definition of telemonitoring in the search is an important strength of study.
- The use of Mendel's framework proved to be a good fit for categorizing the scoping review results.
- A second reviewer encoded a purposeful sample of all extracted text components. No significant differences were identified between the first and second reviewer.

Introduction

Telemonitoring is the collection, transmission, evaluation, and communication of individual health data from a patient to their healthcare provider or extended care team from outside a hospital or clinical office (i.e., the patient's home) using personal health technologies including wireless devices, wearable sensors, implanted health monitors, smartphones, tablets and mobile apps.[1] Pilot studies show that use of telemonitoring supports self-management, for instance by offering direct feedback to the patient.[2] Furthermore, telemonitoring is believed to improves early detection of disease or clinical deterioration and thereby has the potential to reduce hospitalisation and mortality.[2 3 4] In addition, telemonitoring has the potential to monitor patients more frequently or even continuously. As such, use of telemonitoring could improve quality of care, reduce the amount of time a clinician ends up spending to manage patients and increases the frequency of monitoring without increasing workload on healthcare resources.[5-8] Devices with intelligent and reliable computing sensors in wearables, hand-held devices, (smart)phones and implants have become widely available. The World Health Organisation (WHO)[9], the European Union (EU)[10], national governments and other governing organisations promote use of such technology if proven to be valid, reliable and sustainable, attempting to facilitate care at a distance.[11] However, positive results from the aforementioned small pilot studies are difficult to replicate when telemonitoring initiatives are to be implemented on a larger scale.[12 13]

In this review, following the WHO definition, 'upscaling' of telemonitoring is defined as 'the expansion and replication of good practice of a telemonitoring project in more than one independent organisation or setting and across geographical boundaries'.[14]

In order to facilitate larger scale implementation of telemonitoring projects using personal health technologies, evidence is needed regarding the barriers and enablers for successful implementation. A preliminary literature search conducted on January 6 2020 in PubMed, JBI Evidence Synthesis, Open Science Framework registries and the PROSPERO database identified that no systematic reviews, meta-analyses, or scoping reviews on scaling up telemonitoring had been performed and that none were underway.(Appendix 1). Indeed, research in the field of telemonitoring is relatively new and lacks high quality and homogeneous studies on the scaling up of telemonitoring. The purpose is to identify factors of influence on scaling up. Therefore it was decided to perform a scoping review.[15] Scoping reviews are a form of knowledge synthesis that incorporate a range of study designs in order to provide a comprehensive summary.[16]

The aim of this scoping review is to identify current enablers and barriers for upscaling of telemonitoring across various healthcare settings in a structured manner.

Methods

This scoping review was conducted in accordance with the JBI methodology guidance for scoping reviews, using the Preferred Reporting Items for Systematic Reviews and Meta-Analyses – Scoping Reviews (PRISMA-ScR) checklist, which is an extension of the PRISMA checklist.[17 18] The scoping review protocol was registered on March 29th 2021, via the Open Science Framework (https://osf.io/mpq9g/)

Patient and public involvement

Patients and/or the public were not directly involved in this study.

Eligibility criteria

Studies were eligible if they focussed on remote monitoring of patients' vital functions - such as blood pressure, pulse oximetry, temperature and heart rate - by care practitioners or centres, and the monitored data was transmitted digitally via (smart)phone, tablet or Internet. Studies had to describe the implementation or adoption of telemonitoring on a larger scale, for instance in more than one organisation, or in a larger geographical area (larger regions, provinces or nationwide). There were no restrictions on publication year and study design and only full-text publications were included.

Studies were restricted to humans, the English language and peer-reviewed publications. Therefore, ongoing studies, conference abstracts and posters were excluded. Studies reporting self-monitoring by patients only and studies that solely described the effect of telemonitoring but not the implementation or adoption were also excluded.

Search strategy for Scoping Review

The preliminary search identified appropriate keywords and MeSH-terms. Subsequently, a broad search strategy for Pubmed was formulated by three reviewers (HG, NE, MS) and a medical librarian, combining the identified keywords and MeSH-terms related to telemedicine, ehealth, (tele)monitoring, implementation and upscaling. No filters were applied in the final search strategy. The complete PubMed search strategy is outlined in Appendix 2 and was adapted for the other indexed databases. HG performed the literature search of PubMed, EMBASE, Cinahl, Web of Science,

ProQuest and IEEE in January 2020 and updated the search on February 1st 2022. Included studies were cross-referenced to identify additional studies.

Data Extraction and Analysis

One reviewer (HG) removed duplicates and led the process of study screening and selection. Study selection was managed using the online reference manager Rayyan.[19] The search results were reviewed on two sequential levels. In the initial "title and abstract stage", the article titles and abstracts were screened according to the inclusion and exclusion criteria independently by two researchers (HG and TF). The lists of included studies and summaries of the collected data constructed by the two researchers were compared. Any disagreements were resolved by discussion and involvement of a third researcher (DvD). In the second "full-text stage", the remaining articles were examined to ensure that they met the inclusion criteria.

Study characteristics were systematically extracted using a structured data collection form that included the following parameters: type of telemonitoring, study location, year of publication, research methods, patient characteristics, and outcome measures of adoption. The charted data was verified by a second reviewer (TF or DvD).

Interpretation and analysis using Mendel's framework

In addition to the extraction of study characteristics, text components from the included articles, relevant to the nationwide implementation of telemonitoring, were extracted by one of the researchers (HG). The extracted text components were uploaded into a qualitative analysis software program (MAXQDA Analytics Pro, VERBI Software, 2020), and coded to capture all relevant constructs. A second researcher encoded independently of the first researcher 25% of the articles, after which they verified their coding. If there were significant differences between the first and second researcher, the differences were discussed and the procedure repeated.

The structure of the analysis was based on Mendel's framework for Building Evidence on Dissemination and Implementation in Health Services Research[20] (appendix 3). This framework supports the understanding and assessing of relevant contextual factors and dynamics affecting the dissemination, implementation, and sustainability of interventions within communities and healthcare settings. In this scoping review, the "diffusion process" items of Mendel's framework were used to better understand and generalise the relevant contextual factors from different studies involved with nationwide upscaling of telemonitoring.

Results

The search yielded 2927 records. After the removal of duplicates, 2298 titles and abstracts were screened for inclusion and exclusion. 2250 studies were excluded after title and abstract screening, leaving 48 articles for full-text screening. All numbers were used to create a flowchart (Figure 1). Additional details for the reasons of exclusion are presented in Table 1. Finally, a total of 19 articles were included for analysis, describing a variety of telemonitoring solutions.[21-38]

Characteristics of studies

The general characteristics of the included studies are presented in Table 2. Eleven out of 19 articles described a survey[21 22 25 28-30 33 34 36-38], four described focus group interviews[27 31 35 39], three articles were narrative reviews[24 26 32], and one article described the results of a workshop.[40] A total of 89 enabler or barrier factors were mentioned 202 times in 19 studies.

Scale and utilisation of telemonitoring

The utilisation of telemonitoring was reported in 13 of the 19 studies. Reported utilisation varied widely from “not part of routine care, or not available as standard care” in Austria , Norway, Lithuania, the UK and Sweden, to “90% utilisation of tele-electrocardiography” in Brazil.[21 22 28 33 35]

There was significant heterogeneity of the definition of utilisation, which was reported as: number of patients that used telemonitoring[32 36 37 39], percentages of actual use[29], number of clinics that are engaged in telemonitoring[24 36 37], number of hospitals offering telemonitoring for high-risk pregnancies[38], number of projects in a country[30] and total recorded measurements.[37]

The percentages of the actual use of telemonitoring in patients with heart failure varied from 3% to 77%.[25 29 37] In Brazil, a telemonitoring system for the monitoring of heart rhythms with an electrocardiogram was implemented in 79 municipalities. This study showed a utilisation ratio higher than 90%. [22] In Denmark, all telemedicine projects are mapped to provide a national contemporary overview of telemedicine initiatives. Utilisation is reported by referring to a website on which 16 active telemonitoring projects are registered within the country at this moment.[30 41] The enablers and barriers for nationwide upscaling of telemonitoring were structured in three domains using Mendel’s framework: context of diffusion, stages of diffusion and intervention outcomes.

What are the enablers and/or barriers for upscaling of telemonitoring?

Regarding the context of diffusion, the enablers and barriers retrieved were classified into six different categories of contextual factors: being an enabler, a barrier, or both according to Mendel's framework (Figure 2). Table 3 gives an overview of factors and supplementary table 1 describes barriers and/or enablers in more detail.

1. *Norms & Attitudes.*

Primary physicians needed to adapt their standard procedures in order to make an efficient contribution to care using telemonitoring solutions, for example by using the patients' self-measurements instead of doctor's office in-house measurements.[27] Healthcare professionals or centres that are aware of the benefits have a more positive attitude regarding telemonitoring.[29 31 37] In two studies, healthcare professionals had high expectations of working with telemonitoring, as well as managing caseloads more efficiently.[35 36]

A common perceived barrier for professionals is that telehealth can increase workload and make planning work more difficult when responding to monitoring alerts.[35] Across different studies professionals shared the view that patients may become too dependent on the technology making it a clear barrier for the use of telemonitoring.[27 31] Some studies report scepticism or reservations concerning telemonitoring.[21 31 35]

Another important barrier for the diffusion of telemonitoring is the lack of awareness of the possibilities and opportunities for providing care using remote monitoring among both health care management and clinical staff.[40]

2. Organisational Structure & Process.

Eleven studies reported on organisational items.[21 24-28 32 35-37 40] Adoption of telemonitoring requires an infrastructural investment that will take several years to implement and will involve a complete overhaul of existing practice, clinically, financially, and managerially.[40] An elaborate program of change management is described as an enabler in the upscaling and implementation of telemonitoring.[24 40] Change management is described as continuous evaluation and assessment in the refining of patient selection criteria for remote monitoring, and personalising care pathways.[24] Security and privacy aspects influence implementation.[21 24 28 32 37] Setting up appropriate vendor agreements and protocols is described as an enabler concerning responsibility for incoming data.[21 24 28 35 36 40]

3. Resources.

Financial aspects of telemonitoring are described as an important factor in nine studies.[21 24-26 28 35-37 40] For example, a lack of financial resources is described as among the four most important barriers for the adoption of eHealth.[25] Six studies described reimbursement as a barrier for implementation of telemonitoring.[21 24 26 28 33 40] According to these studies a suitable reimbursement solution should be adopted to incentivise and engage all stakeholders and to drive the intended transformation of healthcare delivery. Along with the financial aspects, concern rises for the possible inability to access the telemonitoring system via the electronic medical records.[27 32 35 37 40] Also, a lack of interoperability generates new tasks to share telehealth data with other clinicians via electronic patient records. This also causes concerns whether the telehealth data entered in a patient's record are accurate and relevant. This makes interoperability standards crucial to the success of upscaling remote patient monitoring programs.[32 40]

4. Policies & Incentives.

Three studies indicate that policies governing telehealth may differ at the state level, which forms a barrier for implementation on interstate level.[26 35 40] On a national level, professional societies can issue guidelines to enable telemonitoring.[22 24] European and worldwide policies on innovation friendly, legal and regulatory frameworks may enable upscaling of telemonitoring.[24 26 40]

5. Networks & Linkages.

Four studies described non-profit or public-private collaborations as enablers for implementation of telemonitoring.[24 26 28 32]. For example, a role for professional organisations like the European Society of Cardiology (ESC) in collaboration with national societies is described in catalysing reimbursement and adoption of telemonitoring in cardiac diseases.[24] A national repository could act as the first port of call where policy makers, clinicians, and users could access information of remote monitoring projects.[40] Another approach could be an extended partnership between device companies and health care systems involving telemonitoring services.[26]

At a regional level, collaborative efforts may connect hospital and regional health executives to network leaders, focusing on adoption, scale, and spread of network monitoring solutions. Collaboration between hospitals and primary care providers, within the Ontario Telemedicine Network, proved to be an important factor for the sustainability of a tele homecare program in Canada.[28 32]

6. Media & Change Agents.

Two studies described media and change agents as enablers for the implementation of telemonitoring. Advocates, early adopters and local champions are described as an important source of information and advice for the introduction of telemonitoring.[24 35 37]

Stages of diffusion

Enablers and barriers were reported not to be linked to an implementation stage nor to a specific stage of diffusion. However, based on the reported utilisation and phase of upscaling, it is possible to analyse what stage of diffusion a telemonitoring project is most likely to be in. Eight studies described telemonitoring in the stage of pre adoption. [21 25-28 33 35 36] Six studies described telemonitoring in the implementation stage. [24 31 32 37 39] Only two studies described telemonitoring projects in the phase of sustainment. [22 32] In three studies it was not possible to analyse the stage of diffusion.

Intervention outcomes

Enablers and barriers for implementation may affect outcomes for individuals in the community, as well as local organisations and systems of care. All the expected outcomes for implementation of telemonitoring are described in table 4.

Patient Care & Health Outcomes. Six studies reported outcomes on an individual level and in what way they were expected to be affected by telemonitoring. For example, implementation of telemonitoring was expected to improve self-care or patient empowerment. [21 24 27 28 36 40]

Organisation & System Outcomes.

Five studies reported on the expected outcomes on an organisational and system level. For example, when telemonitoring was implemented, it was expected that more patients could be treated, which would reduce admission and visits [21 24 28 33 40], workload would be reduced [21 28 33] and costs would be reduced.[21 24 28]

Discussion

This scoping review provides insight into the enablers and/or barriers that affect upscaling of telemonitoring in healthcare across different settings. All included studies examined large scale adoption or implementation of telemonitoring. One study described an International and European scale up.[37] This review retrieves and identifies important overarching factors, relevant for nationwide upscaling.

One of the most frequently mentioned factors of influence is “costs” or “reimbursement”. For example; providing an eHealth infrastructure for free throughout the project duration is a great enabler.[37] Reimbursement is mentioned as a solution - “a suitable reimbursement solution should be adopted”[24] – or as a barrier: “there is no financial backing to adopt new systems such as remote monitoring”.[40] Economic evaluations of eHealth applications are gaining momentum, and studies have shown considerable variation regarding the costs and benefits that they include.[42] Economic studies on telemonitoring in heart failure and women at risk of preeclampsia describe this duality. The initial cost of the telemonitoring equipment may be an obstacle to widespread use of telemonitoring. Although telemonitoring will require an initial financial investment, economic studies show substantially reduction of costs in the long term.[43 44] Costs, as a factor of influence, exist in coherence of “a lack of evidence”. In the absence of solid empirical evidence, key decision makers may doubt the effectiveness of eHealth, which, in turn, limits investment and its long-term integration into the mainstream health care system.[45] Exploring alternative payment models, for example “temporary” funding of telemonitoring by health insurers, could bridge that gap so that the necessary evidence can be collected.

Over half of the factors identified are stated both as an enabler and a barrier. Therefore, factors of influence found in this scoping review can be used pragmatically; e.g. as a directive to check whether the factor is a barrier or an enabler in projects where upscaling is required. A relatively large number of factors are related to the “norms & attitudes” of users. Although this is an important factor for local implementation, one would expect that proportionately more context-related factors for nationwide scaling up would be found. Resources, attitudes, intrinsic motivation and behaviour of end-users, costs and technical knowledge of health care providers are all important factors of influence. These findings are consistent with reviews on implementation of other types of eHealth or telemedicine.[13 46-49]

The utilisation and upscaling of telemonitoring varied widely across settings and was not reported in 30% of the included studies. Because adoption is not clearly defined in the studies it is not possible to interpret the enablers and barriers for each phase of adoption. In future studies, it is recommended to give a clear definition of adoption and to report utilisation. Only then is it possible to learn more about barriers and facilitators in various stages of implementation to scale up.

Studies in this scoping review reported expected “patient care & health outcomes”. Outcomes were not correlated to certain enablers or barriers. Based on this scoping review it is not possible to draw

conclusions regarding factors of upscaling influence the outcomes of care, nor which outcomes of care influence the upscaling. Although it would be useful to know more about upscaling of telemonitoring in relation to specific patients conditions, this study focused on the possible facilitators and barriers for (nation)wide upscaling regardless of patient conditions.

Practical implications

Based on the findings in this study, a coordinated and structured collaborative approach enables the upscaling of telemonitoring, embodying:

A wide program on change management, including policies and protocols on adaption of healthcare processes; Implementation coordinators, who set up requirement specifications with particular attention to interoperability standards, telemonitoring access to electronic medical records, security and privacy aspects, and appropriate vendor agreements; Widespread marketing and recruitment initiatives, for example social media channels that enable the recruitment of participating centres; Collaboration among different hospitals and between primary care and hospitals, as a way to overcome organisational and regional differences and to create an economy of scale, and;

New and innovative ways for reimbursement.

There was disagreement during the selection of studies that required discussion with a third reviewer. There are studies in which blood pressure is measured automatically at home. However, the data of these measurements were not exchanged electronically with the hospital in these studies. Studies investigating this form of home measurement have not been included in this scoping review. Narrowing down the definition of telemonitoring in the search is an important strength of study. A range of terms like “remote monitoring”, “teleconsultation”, “telehealth” or “telecare” is used interchangeably in the definition of telemonitoring. There are 23 different exclusion reasons for 2015 exclusions due to the terminology of telemonitoring. (Table 1). For example; teleconsultation, video-consultation and remote monitoring by telephone calls are all described as telemonitoring and 355 studies used “telemonitoring” as a keyword for a mobile health application without telemonitoring functionality. Using this precise definition of telemonitoring makes it possible to compare the results of this study with future studies on upscaling telemonitoring. Another strength of this study is the use of Mendel’s framework, which provided to be fit for categorizing the scoping review results on upscaling of telemonitoring across the included studies.

This review analysed search results from four well-known research databases. It uses key terms registered with MeSH, and multiple reviewers determined the inclusion and exclusion criteria. A limitation to this study could be the coding of extracted text components by the second reviewer,

who coded only a purposeful sample of all studies. However, no significant differences were identified between the first and second reviewer, therefore it is unlikely that this resulted in bias.

Due to the large amount of heterogeneity in the included studies with regard to study design, types of telemonitoring, and measurement of adoption or utilisation, advice on how to scale up a telemonitoring project within countries has to be made carefully. For future research it is desirable to use a clear and narrow definition of telemonitoring, utilisation and outcome measures.

Conclusion and recommendations

We live in a world where telemonitoring rapidly integrates into preventive and clinical care and well-being. Successful upscaling of telemonitoring requires insight into the factors of influence in adoption, especially at an overarching national level. To futureproof and facilitate upscaling of telemonitoring it is recommended to find means for reimbursement to use this type of technology in usual care and to explore alternative payment models early on. A wide program on change management, national or regional coordinated, is key. Clear regulatory conditions and professional guidelines may further facilitate widespread adoption and use of telemonitoring. The results of this study can be used to help develop a guideline for upscaling.

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Figure legends

Figure 1. PRISMA flowchart showing the process of including and excluding studies.

Figure 2. The number of enablers, barriers, or both regarding the context of diffusion according to Mendel's framework.

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Table 1 Reasons for exclusion.

# excluded		Reasons
2279	2015	Not describing telemonitoring as defined in the inclusion criteria; but described 569 teleconsultation 355 mHealth applications (without telemonitoring functionality) 251 health informatics topic in general 126 implementation of an EHR 105 e-mental health 61 lifestyle promotion 44 internet based therapy 23 tele-dermatology 22 tele-rehabilitation 19 e-prescription 18 addiction related 15 related to systems and technology 12 tele-ICU 12 smart home (care) 10 teledentistry 9 AI related 9 tele-ophtalmology 5 e-registries 5 teleradiology 5 blockchain 3 background articles 2 teleaudiology, 2 internet of things, 2 robotics, 1 RFID, 1 AR/VR 325 excluded for not describing telemonitoring with other reasons
	146	articles described a telemonitoring or eHealth project, without describing implementation or adoption.
	57	Articles described telemonitoring implementation, but not in more than one independent organisation or setting and across geographical boundaries.
	26	study protocol
	24	opinion papers or interviews
	15	non-English

EHR = Electronic Health Record, mHealth = mobile Health, RFID = Radio-frequency identification, tele-ICU = tele intensive care unit, AI = artificial intelligence, AR/VR = augmented reality / virtual reality.

Table 2 Study characteristics

#	Study and year	Country	Design	Condition	Type of telemonitoring	Analysis	Outcome measures for adoption
1	Aamodt 2019[21]	Norway and Lithuania	Cross-sectional survey	Heart failure care	Body weight, blood pressure, heart rate, dyspnea	Summative content analysis	Reported as not part of routine care / standard care
2	Alkmim 2019 [22]	Brazil	Survey	Cardiology	Tele-ECG	Descriptive statistics	Utilisation>3days per week
3	Chronaki 2013 [24]	Europe	Narrative review	Diverse	Tele-ECG	N.a.	Health care costs + number of clinics engaging in TM
4	Cook 2016 [39]	UK	Qualitative semi-structured interviews	COPD	Telehealth: Pulse oximetry, temperature, pulse, blood pressure	Framework method	N.a.
5	Diaz-Skeete[40]	Republic of Ireland	Workshop report	Cardiac care	n.a.	n.a.	n.a.
6	Faber, 2017 [25]	Netherlands	Survey	Heart failure + diabetes	N.a.	Structured equation modelling approach	Extent of adoption in percentages
7	Fraiche 2017 [26]	US	Narrative review	Heart failure	Blood pressure, weight, ECG	N.a.	N.a.
8	Hanley 2018 [27]	Scotland	Qualitative interview + focus groups	COPD, hypertension, BP after stroke, COPD, heart failure, diabetes	SpO2, BP, blood glucose,	Interpretive description approach and thematic analysis	N.a.
9	Kato 2015 [28]	Japan and Sweden	Cross-sectional survey	Heart failure	Monitoring physical condition and noticing a decline	Descriptive analysis and content analysis methodology	4 domains Reported as not part of routine care
10	Klack, 2013 [29]	Germany	Survey	Heart patient	weight, temperature, blood pressure, coagulation	Descriptive statistics	Physician and engineers perspectives Extent of adoption in percentages
11	Kristensen 2019 [30]	Denmark	Email survey	Chronic heart failure, atrial	Blood pressure, heart rhythm,	Number of initiatives in	Number of projects

				fibrillation, COPD, ADHD, Pregnant with complications, hypertension, patients with an ICD	body weight, heart rate, blood glucose,	interactive map online	registered.
12	MacNeill, 2014 [31]	UK	Semi structured qualitative interviews	Chronic heart disease, COPD and diabetes	Blood pressure, weight, oxygen, blood glucose	Modified grounded theory	
13	McGillion 2018 [32]	Canada	Narrative review	Surgical population	Respiratory rate, blood pressure, heart rate, SpO2, temperature	N.a.	N.a.
14	Muigg, 2019 [33]	Austria	Cross-sectional survey	Diabetes	Blood pressure and blood glucose	Qualitative content analysis	Reported as not part of routine care
15	Okazaki, 2013 [34]	Japan and Spain	Survey	Not specified	Not specified	Causal modeling	n.a.
16	Taylor, 2014 [35]	UK	Qualitative interviews	COPD and Chronic heart failure	Not specified	Thematic analysis	n.a.
17	de Vries, 2013 [36]	Netherlands	Survey	Heart failure	Blood pressure, weight, heart frequency, ECG	Descriptive statistics	Usage
18	Van den Heuvel[38] 2020	Netherlands	Survey	Women with pregnancy complications	Cardiotocography	Descriptive statistics	Provision of telemonitoring and perspectives of respondents
19	Gawalko[37] 2021	Europe	Survey	Management of atrial fibrillation	Remote PPG or 1-lead ECG	Descriptive statistics	Centre experience and patient experience.

n.a. = not available

Table 3. An overview of factors, classified by the "diffusion process" items of Mendel's framework

	#Factors	#Described	#Barriers	#Enablers	#Both
1. Norms & Attitudes	31	51	12	10	9
2. Structure & Process	16	33	3	3	10
3. Resources	19	75	2	2	15
4. Policies & Incentives	10	23	0	1	9
5. Networks & Linkages	3	8	1	1	1
6. Media & Change agents	10	12	0	9	1
Total	**89**	**202**	**18**	**26**	**45**

The number of times factors of influence were described in total; and the number of times factors were described as barrier, enabler or both.

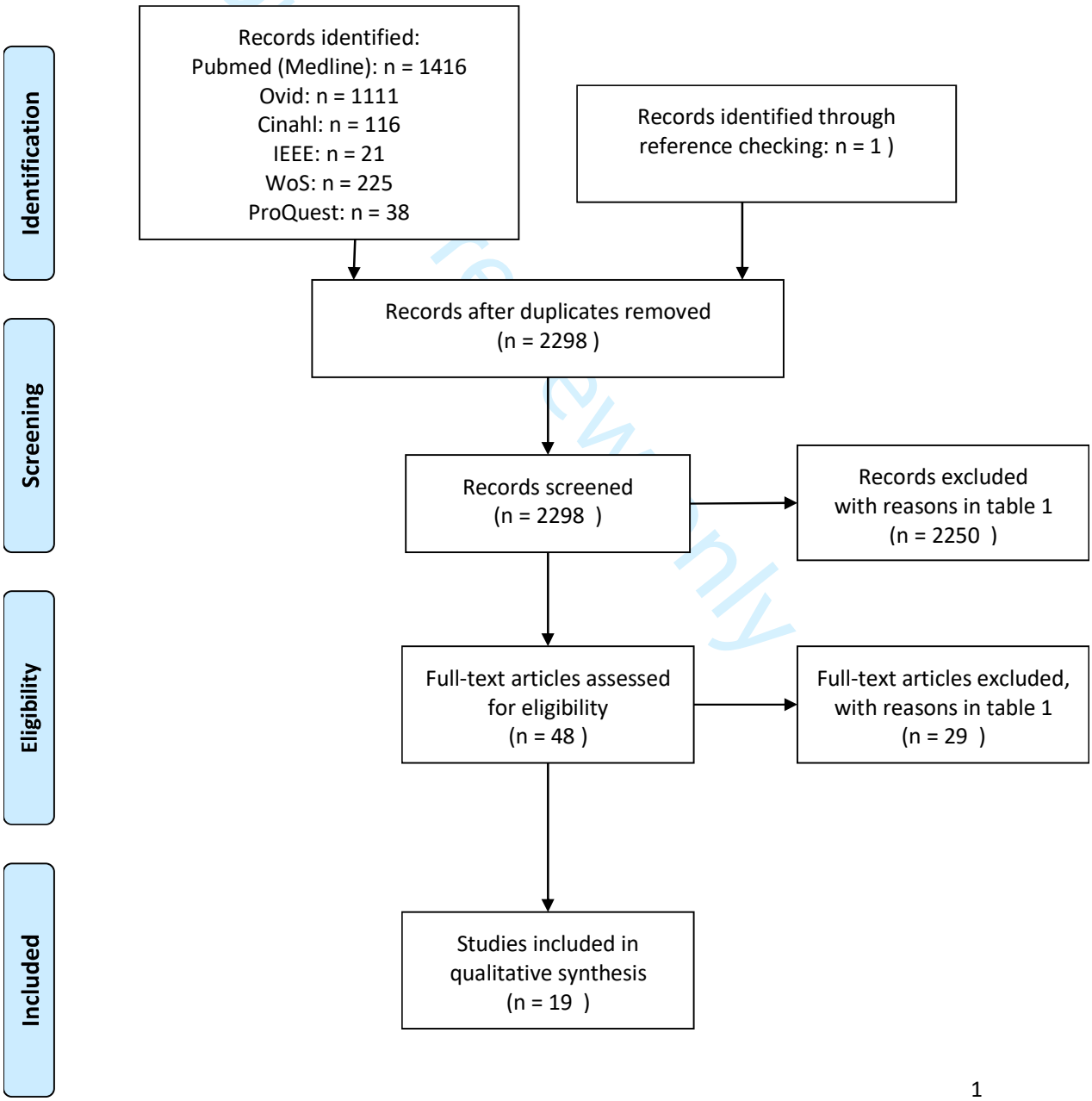
Table 4. The (expected) intervention outcomes when telemonitoring is implemented.

Domain	Contextual factors	Detailed description	Number of publications mentioned
Intervention outcomes	Patient care & health outcomes	(improve) self-care or patient empowerment [21 24 27 28 36 40]	6
		(improve) quality of care [21 28 33 36 40]	4
		(improve) patient education [21 28 36]	3
		(improve) symptoms of disease [28 36]	2
		(improve) quality of life [24]	1
	Organisation & System outcomes	Treat more patients (and reduce admission and visits) [21 24 28 33 36 40]	5
		(reduce) workload [21 28 33 36]	4
		(reduce) costs [21 24 28]	3
		(improve) adherence to guidelines [21 36]	2
		Contribute to continuity of care [24]	1

Figure 1 PRISMA flowchart showing the process of including and excluding studies.

Search syntax:

("Telemedicine"[Mesh] OR telemedicine[tiab] OR mhealth[tiab] OR m-health[tiab] OR ehealth[tiab] OR e-health[tiab] OR out-of-office[tiab])
AND
("Monitoring, Physiologic"[Mesh] OR "Monitoring, Ambulatory"[Mesh] OR monitor*[tiab] OR telemonitor*[tiab] OR health care[tiab] OR healthcare[tiab])
AND
("Implementation Science"[Mesh] OR "Health Plan Implementation"[Mesh]
AND
scale up[tiab] OR implement*[tiab] OR adoption[tiab])
AND
("Health Policy"[Mesh] OR "Policy Making"[Mesh] OR "National Health Program "[Mesh] OR policy[tiab] OR survey*[tiab] OR mapping[tiab])



Number of factors that influence upscaling

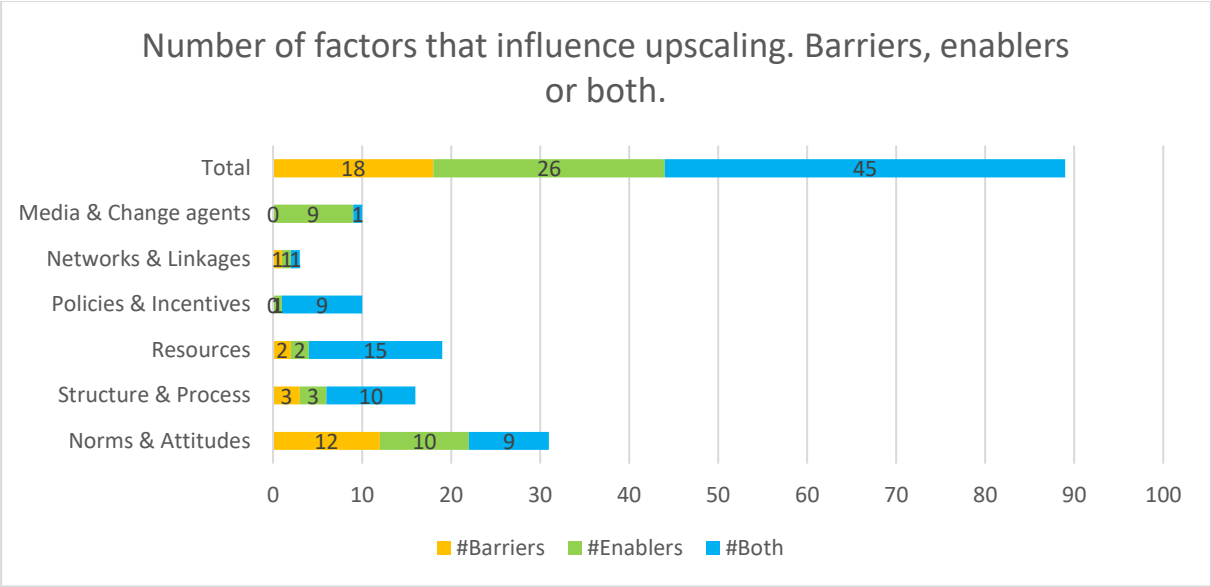


Figure 2. The number of enablers, barriers, or both regarding the context of diffusion according to Mendel's framework.

Supplementary Table 1. Overview of factors – enablers and/or barriers – that influence nationwide upscaling of telemonitoring.

Domain	Contextual factors	Detailed description	Barrier, Enabler or Both	Number of times mentioned in publications
Context of diffusion	Norms & Attitudes	HCP think that patients become too dependent on technology[27 31 39]	Barrier	4
		HCP have scepticism or reservations about TM[28 31 35]	Barrier	3
		There must be a perceived usefulness and usability of equipment [27 31 39]	Both	3
		TM is convenient for patients [27 31 37]	Enabler	3
		HCP have a positive attitude (towards usefulness, feasibility, potential) [29 31 37]	Enabler	3
		There is concern amongst HCP that acting on the TM data provided could lead to overtreatment[27 31]	Barrier	2
		HCP consider use of TM relevant [21 28]	Enabler	2
		HCP have high expectations of working with TM[36]	Both	2
		TM makes patients anxious [27 31]	Barrier	2
		HCP think that TM can increase workload and make planning more difficult[35 36]	Barrier	2
		Make patients feel more empowered to take a pro-active approach to their health[27] or should be empowered to engage with technologies for selfmanagement and self-care purposes[40]	Enabler	2
		HCP perceive a shift to technology making medical decisions or support in medical decision making[29 37]	Both	2
		Although the HCP had high perceptions and expectations of working with TM, these were not positively reflected in the actual experiences.[36]	Barrier	1
		HCP expect to manage caseload more efficiently[35]	Enabler	1
		Change personal practice[27]	Both	1
		Concerns about the impact of telehealth on nursing roles[35]	Barrier	1
		HCP experience a lack of advantage[28]	Barrier	1

		HCP who have the knowledge and experience in TM, tend to have a less positive attitude compared with technical professionals, who might be driven by their greater enthusiasm for technology in general.[29]	Both	1
		HCP think that TM is more expensive than conventional treatment[29]	Barrier	1
		Technical professionals are more confident about patient compliance then HCP [29]	Both	1
		HCP concern about privacy protection[29]	Barrier	1

		HCP concern about the loss of control over the medical treatment[29]	Barrier	1
		HCP think that patient acceptance is a factor of influence[37]	Both	1
		Use of telehealth is an important new skill for HCP, as was the ability to understand trends in the management of long-term conditions[31]	Enabler	1
		HCP see TM as an opportunity for professional career development[31]	Enabler	1
		HCP consider "Our centre is innovative" [21]	Enabler	1
		Patients need to accept their old age and health condition, before they use TM [39]	Both	1
		Reducing the level of face-to-face contact with the patients was a concern for professionals, but this concern was not universally shared by patients, some of whom experienced the non-face-to-face contact as additional and efficient input.[27]	Enabler	1
		HCP have concerns about the appropriateness of telehealth for the very severely ill[31]	Barrier	1
		Early positive experiences and the sharing of success were identified as key enablers for staff acceptance. Early negative experiences of telehealth have a long-lasting impact on staff acceptance and the predominant view among participants[35]	Both	1
		HCP state that telemonitoring provides higher patient satisfaction (related to home-monitoring) and does not require hospital staff to visit patients at home [38]	Enabler	1
	Organisational structure & process	Security and privacy aspects that influence implementation [21 24 28 32 38 40]	Both	6
		Rules and protocols on the implementation of the system and responsibility for incoming data[21 28 35 36 40]	Both	5
		Certain processes / coordination support implementation of TM [28 32 35 36]	Both	4

		Use of TM enables clinical decision support and influence adoption of guidelines [24 26 27]	Enabler	3
		Regular data sharing had a motivating effect on patients, as they were aware that at some point the readings may be reviewed [27] or is a possible limitation[40]	Both	2
		A wide program of change management to support healthcare transformation and adoption of new working practices [24 40]	Both	2
		Reduce admissions or readmissions [21 36]	Enabler	2
		Creating central databases making the transmitted data accessible to the treating physician and serving as data registries that benefit medical research [24]	Enabler	1
		Set up appropriate vendor agreements and infrastructure [24]	Both	1
		Protocols on the acceptable length of time between the moment of incoming patient data and the response of the HCP(response-reaction time) [36]	Both	1
		Difficult to obtain relevant data about patients and ensuring that relevant data –	Barrier	1

		limited tailoring to individual patient - is shared with HCP [35]		
		Limited options for discharging patients who will benefit from continued use [35]	Barrier	1
		Referral routes should be opened up for patients with other conditions and with less complex needs [35]	Both	1
		A changing environment is a barrier [35]	Barrier	1
		The introduction (the way of communication, red.) to frontline staff influences implementation [35]	Both	1
		Organisational size influences implementation of TM [25]	Both	1
	Resources	Costs / financing of TM [21 24-26 28 35-38]	Both	9
		Knowledge of HCP / training of frontline staff [21 24 28 32 35-37 40]	Both	8
		Reimbursement as an element of financial resources[21 24 26 28 33 37 38 40]	Both	8
		The TM-system access to the EMR / interfacing of technologies [24 26 27 32 35 37]	Both	6
		Design of telemonitoring system / usability [26 27 32 37 39 40]	Both	6
		Availability of equipment [21 28 35 37]	Both	5
		Sufficient staffing [26 28 32 37 40]	Both	5

		Time for implementation TM [27 32 35]	Both	5
		Lack of evidence for TM [21 24 26 40]	Both	4
		Engage stakeholders in system design [32 35 40]	Both	4
		(Lack of)Cloud acces, internet access or cellular access [28 32 37]	Both	3
		Organisational readiness [25 33]	Both	2
		Significant income disparities which impact the ability to enforce guidelines and advance adoption of TM [24]	Barrier	2
		An externally resourced system for installation, technical support, maintenance and de-installation [35 37]	Both	2
		Local “champions” [35]	Both	1
		Top management support [25 40]	Both	1
		Staff to assume monitoring and management responsibilities for patients outside the hospital [26]	Both	1
		On-boarding process to a TM project. [37]	Both	1
		(Patient)education to address concerns regarding the use of remote monitoring , specifically for older adults, as an enabler [40]	Enabler	1
		Assessment of added value should be calculated [38]	Enabler	1
	Policies & Incentives	Addressing security, social and ethical issues to enable implementation of TM [24 28 32 37 38]	Both	5
		A (lack of) vision of an organisation on implementing TM [21 28 35]	Both	3
		Worldwide, European and statelevel policies and legal and regulatory frameworks [24 26 40]	Both	3
		New or adjusted workflows, care paths or data management [24 27 37]	Both	3
		Consensus statements and national guidelines [22 24]	Both	2
		Reimbursement or alternative payment models as a financial incentive for organisations [24 26]	Both	2
		Target patients, volume of population, data load and work intensity within organisations [28 35 37]	Both	3
		Interoperability standards crucial to the success of scaling remote patient monitoring programs [32]	Both	1

		Policy and practice developments affecting health care services [35]	Both	1
		Importance of TM for health authorities [21]	Enabler	1
	Networks & Linkages	Collaboration non-profit or public-private organisations [22 24 26 35 40]	Both	5
		Not being able to collaborate with other hospitals or clinics and primary care providers [28 32]	Barrier	2
		Professional organisations in collaboration with national societies can play an important role in catalysing reimbursement and adoption [24]	Enabler	1
	Media & Change Agents	Advocates, early adopters and local champions enable implementation of TM [24 35]	Enabler	2
		Create (and increase) awareness in the general clinical community of the potential that remote monitoring has [37 40]	Enabler	2
		A standardized initiation video call to inform and instruct each participating centre[37]	Enabler	1
		(Lack of) guidelines from health care authorities [21]	Both	1
		Device manufacturer that invest in TM [24]	Enabler	1
		The dynamics in the COVID-19 pandemic may have impacted the use of TM[37]	Enabler	1
		Consensus on the implementation and research agenda can pave the road to the widespread use of digital health services[38]	Enabler	1
		A national repository could act as the first port of call where policy makers, clinicians and users could access information on remote monitoring projects[40]	Enabler	1
		Information about strategies to educate and empower patients were provided[37]	Enabler	1
		Professional societies can review and potentially endorse TM applications that offer valuable decision support and empower the physician's relationship to the patient [24]	Enabler	1

HCP= Health Care Professional, **TM**= Telemonitoring

Appendix 1. Preliminary search

Database	Search syntax	Results
Pubmed	("Telemedicine"[Mesh] OR telemedicine[tiab] OR mhealth[tiab] OR m-health[tiab] OR ehealth[tiab] OR e-health[tiab]) AND ("Monitoring, Physiologic"[Mesh] OR "Monitoring, Ambulatory"[Mesh] OR telemonitor*[tiab]) AND ("Implementation Science"[Mesh] OR "Health Plan Implementation"[Mesh] AND scale up[tiab] OR implement*[tiab] OR adoption[tiab])	723 of which 156 meta-analysis or reviews. None relevant for upscaling telemonitoring
JBI Evidence Synthesis	Telemonitoring AND Implementation	14 results, none relevant.
Open Science framework	Telemonitoring OR telemedicine	29 registries, none about upscaling
Prospero database	(telemonitoring [all fields] OR telemedicine [MeSH]) AND Implementation Science [MeSH] OR Regional Health Planning [MeSH] OR Health Plan Implementation [MeSH] OR Implementation [all fields]	102 results, none relevant for upscaling telemonitoring.

Appendix 2. Search syntax

Search syntax:

("Telemedicine"[Mesh] OR telemedicine[tiab] OR mhealth[tiab] OR m-health[tiab] OR ehealth[tiab] OR e-health[tiab] OR out-of-office[tiab])

AND

("Monitoring, Physiologic"[Mesh] OR "Monitoring, Ambulatory"[Mesh] OR monitor*[tiab] OR telemonitor*[tiab] OR health care[tiab] OR healthcare[tiab])

AND

("Implementation Science"[Mesh] OR "Health Plan Implementation"[Mesh]

AND

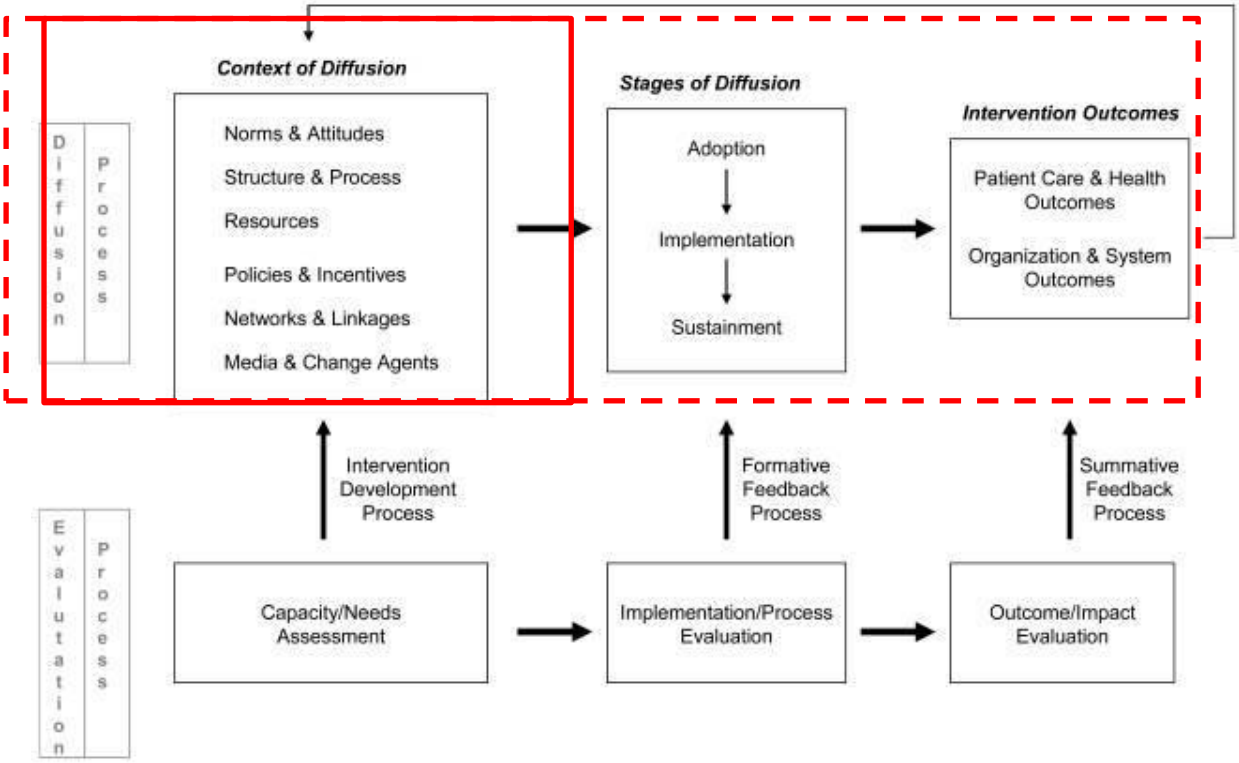
scale up[tiab] OR implement*[tiab] OR adoption[tiab])

AND

("Health Policy"[Mesh] OR "Policy Making"[Mesh] OR "National Health Program "[Mesh] OR policy[tiab] OR survey*[tiab] OR mapping[tiab])

Appendix 3

Framework of dissemination in health services intervention research. From: Mendel et al 2008, Adm Policy Ment Health (2008) 35:21–37. The red lined box indicates the focus in this scoping review.



Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR) Checklist

SECTION	ITEM	PRISMA-ScR CHECKLIST ITEM	REPORTED ON PAGE #
TITLE			
Title	1	Identify the report as a scoping review.	1
ABSTRACT			
Structured summary	2	Provide a structured summary that includes (as applicable): background, objectives, eligibility criteria, sources of evidence, charting methods, results, and conclusions that relate to the review questions and objectives.	2
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of what is already known. Explain why the review questions/objectives lend themselves to a scoping review approach.	4
Objectives	4	Provide an explicit statement of the questions and objectives being addressed with reference to their key elements (e.g., population or participants, concepts, and context) or other relevant key elements used to conceptualize the review questions and/or objectives.	4
METHODS			
Protocol and registration	5	Indicate whether a review protocol exists; state if and where it can be accessed (e.g., a Web address); and if available, provide registration information, including the registration number.	5
Eligibility criteria	6	Specify characteristics of the sources of evidence used as eligibility criteria (e.g., years considered, language, and publication status), and provide a rationale.	5
Information sources*	7	Describe all information sources in the search (e.g., databases with dates of coverage and contact with authors to identify additional sources), as well as the date the most recent search was executed.	5
Search	8	Present the full electronic search strategy for at least 1 database, including any limits used, such that it could be repeated.	Appendix 1 and appendix 2
Selection of sources of evidence†	9	State the process for selecting sources of evidence (i.e., screening and eligibility) included in the scoping review.	6
Data charting process‡	10	Describe the methods of charting data from the included sources of evidence (e.g., calibrated forms or forms that have been tested by the team before their use, and whether data charting was done independently or in duplicate) and any processes for obtaining and confirming data from investigators.	6
Data items	11	List and define all variables for which data were sought and any assumptions and simplifications made.	6
Critical appraisal of individual sources of evidence§	12	If done, provide a rationale for conducting a critical appraisal of included sources of evidence; describe the methods used and how this information was used in any data synthesis (if appropriate).	N/A
Synthesis of results	13	Describe the methods of handling and summarizing the data that were charted.	6

SECTION	ITEM	PRISMA-ScR CHECKLIST ITEM	REPORTED ON PAGE #
RESULTS			
Selection of sources of evidence	14	Give numbers of sources of evidence screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally using a flow diagram.	Page 7, figure 1 and table 1.
Characteristics of sources of evidence	15	For each source of evidence, present characteristics for which data were charted and provide the citations.	Page 7 and table 2
Critical appraisal within sources of evidence	16	If done, present data on critical appraisal of included sources of evidence (see item 12).	N/A
Results of individual sources of evidence	17	For each included source of evidence, present the relevant data that were charted that relate to the review questions and objectives.	Page 7 and 9, table 2, table 3 and table 4.
Synthesis of results	18	Summarize and/or present the charting results as they relate to the review questions and objectives.	Page 9, 10 and 11
DISCUSSION			
Summary of evidence	19	Summarize the main results (including an overview of concepts, themes, and types of evidence available), link to the review questions and objectives, and consider the relevance to key groups.	12, 13
Limitations	20	Discuss the limitations of the scoping review process.	14
Conclusions	21	Provide a general interpretation of the results with respect to the review questions and objectives, as well as potential implications and/or next steps.	14
FUNDING			
Funding	22	Describe sources of funding for the included sources of evidence, as well as sources of funding for the scoping review. Describe the role of the funders of the scoping review.	15

JBI = Joanna Briggs Institute; PRISMA-ScR = Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews.

* Where *sources of evidence* (see second footnote) are compiled from, such as bibliographic databases, social media platforms, and Web sites.

† A more inclusive/heterogeneous term used to account for the different types of evidence or data sources (e.g., quantitative and/or qualitative research, expert opinion, and policy documents) that may be eligible in a scoping review as opposed to only studies. This is not to be confused with *information sources* (see first footnote).

‡ The frameworks by Arksey and O'Malley (6) and Levac and colleagues (7) and the JBI guidance (4, 5) refer to the process of data extraction in a scoping review as data charting.

§ The process of systematically examining research evidence to assess its validity, results, and relevance before using it to inform a decision. This term is used for items 12 and 19 instead of "risk of bias" (which is more applicable to systematic reviews of interventions) to include and acknowledge the various sources of evidence that may be used in a scoping review (e.g., quantitative and/or qualitative research, expert opinion, and policy document).

From: Tricco AC, Lillie E, Zarin W, O'Brien KK, Colquhoun H, Levac D, et al. PRISMA Extension for Scoping Reviews (PRISMAScR): Checklist and Explanation. Ann Intern Med. 2018;169:467–473. doi: 10.7326/M18-0850.

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Enablers and barriers in upscaling telemonitoring across geographic boundaries: a scoping review

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Keywords:	Change management < HEALTH SERVICES ADMINISTRATION & MANAGEMENT, Health informatics < BIOTECHNOLOGY & BIOINFORMATICS, Telemedicine < BIOTECHNOLOGY & BIOINFORMATICS

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Enablers and barriers in upscaling telemonitoring across geographic boundaries: a scoping review

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#title: 12

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#words body: 3520

#figures: 2

#tables: 5

#appendix: 3

#words references: 1485

Abstract

Introduction and objective: Telemonitoring is a method to monitor a person's vital functions via their physiological data at distance, using technology. Whilst pilot studies on the proposed benefits of telemonitoring show promising results, it appears challenging to implement telemonitoring on a larger scale. The aim of this scoping review is to identify the enablers and barriers for upscaling of telemonitoring across different settings and geographical boundaries in healthcare.

Methods: PubMed, EMBASE, Cinahl, Web of Science, ProQuest and IEEE databases were searched. Resulting outcomes were assessed by two independent reviewers. Studies were considered eligible if they focused on remote monitoring of patients' vital functions and data was transmitted digitally. Using scoping review methodology, selected studies were systematically assessed on their factors of influence on upscaling of telemonitoring.

Results: A total of 2298 titles and abstracts were screened and 19 articles were included for final analysis. This analysis revealed 89 relevant factors of influence: 26 were reported as enabler, 18 were reported as barrier and 45 factors were reported being both. The actual utilisation of telemonitoring varied widely across studies. The most frequently mentioned factors of influence are: resources such as costs or reimbursement, access or interface with electronic medical record and knowledge of frontline staff.

Conclusion: Successful upscaling of telemonitoring requires insight into its critical success factors, especially at an overarching national level. To futureproof and facilitate upscaling of telemonitoring it is recommended to use this type of technology in usual care and to find means for reimbursement early on. A wide program on change management, nationally or regionally coordinated, is key. Clear regulatory conditions and professional guidelines may further facilitate widespread adoption and use of telemonitoring. Future research should focus on converting the 'enablers and barriers' as identified by this review into a guideline supporting further nationwide upscaling of telemonitoring.

Keywords: telemonitoring, scoping review, upscaling, implementation, remote health monitoring, digital health, technology, e-health

Article summary – strengths and limitations

- This scoping review uses a transparent methodological approach supported by the application of an established methodological framework.
- Narrowing down the definition of telemonitoring in the search is an important strength of study.
- The use of Mendel's framework proved to be a good fit for categorizing the scoping review results.
- A second reviewer encoded a purposeful sample of all extracted text components. No significant differences were identified between the first and second reviewer.

Introduction

Telemonitoring is the collection, transmission, evaluation, and communication of individual health data from a patient to their healthcare provider or extended care team from outside a hospital or clinical office (i.e., the patient's home) using personal health technologies including wireless devices, wearable sensors, implanted health monitors, smartphones, tablets and mobile apps.[1] Pilot studies show that use of telemonitoring supports self-management, for instance by offering direct feedback to the patient.[2] Furthermore, telemonitoring is believed to improves early detection of disease or clinical deterioration and thereby has the potential to reduce hospitalisation and mortality.[2 3 4] In addition, telemonitoring has the potential to monitor patients more frequently or even continuously. As such, use of telemonitoring could improve quality of care, reduce the amount of time a clinician ends up spending to manage patients and increases the frequency of monitoring without increasing workload on healthcare resources.[5-8] Devices with intelligent and reliable computing sensors in wearables, hand-held devices, (smart)phones and implants have become widely available. The World Health Organisation (WHO)[9], the European Union (EU)[10], national governments and other governing organisations promote use of such technology if proven to be valid, reliable and sustainable, attempting to facilitate care at a distance.[11] However, positive results from the aforementioned small pilot studies are difficult to replicate when telemonitoring initiatives are to be implemented on a larger scale.[12 13]

In this review, following the WHO definition, 'upscaling' of telemonitoring is defined as 'the expansion and replication of good practice of a telemonitoring project in more than one independent organisation or setting and across geographical boundaries'.[14]

In order to facilitate larger scale implementation of telemonitoring projects using personal health technologies, evidence is needed regarding the barriers and enablers for successful implementation. A preliminary literature search conducted on January 6 2020 in PubMed, JBI Evidence Synthesis, Open Science Framework registries and the PROSPERO database identified that no systematic reviews, meta-analyses, or scoping reviews on scaling up telemonitoring had been performed and that none were underway.(Appendix 1). Indeed, research in the field of telemonitoring is relatively new and lacks high quality and homogeneous studies on the scaling up of telemonitoring. The purpose is to identify factors of influence on scaling up. Therefore it was decided to perform a scoping review.[15] Scoping reviews are a form of knowledge synthesis that incorporate a range of study designs in order to provide a comprehensive summary.[16]

The aim of this scoping review is to identify current enablers and barriers for upscaling of telemonitoring across various healthcare settings in a structured manner.

Methods

This scoping review was conducted in accordance with the JBI methodology guidance for scoping reviews, using the Preferred Reporting Items for Systematic Reviews and Meta-Analyses – Scoping Reviews (PRISMA-ScR) checklist, which is an extension of the PRISMA checklist.[17 18] The scoping review protocol was registered on March 29th 2021, via the Open Science Framework (https://osf.io/mpq9g/)

Patient and public involvement

Patients and/or the public were not directly involved in this study.

Eligibility criteria

Studies were eligible if they focussed on remote monitoring of patients' vital functions - such as blood pressure, pulse oximetry, temperature and heart rate - by care practitioners or centres, and the monitored data was transmitted digitally via (smart)phone, tablet or Internet. Studies had to describe the implementation or adoption of telemonitoring on a larger scale, for instance in more than one organisation, or in a larger geographical area (larger regions, provinces or nationwide). There were no restrictions on publication year and study design and only full-text publications were included.

Studies were restricted to humans, the English language and peer-reviewed publications. Therefore, ongoing studies, conference abstracts and posters were excluded. Studies reporting self-monitoring by patients only and studies that solely described the effect of telemonitoring but not the implementation or adoption were also excluded.

Search strategy for Scoping Review

The preliminary search identified appropriate keywords and MeSH-terms. Subsequently, a broad search strategy for Pubmed was formulated by three reviewers (HG, NE, MS) and a medical librarian, combining the identified keywords and MeSH-terms related to telemedicine, ehealth, (tele)monitoring, implementation and upscaling. No filters were applied in the final search strategy. The complete PubMed search strategy is outlined in Appendix 2 and was adapted for the other indexed databases. HG performed the literature search of PubMed, EMBASE, Cinahl, Web of Science,

ProQuest and IEEE in January 2020 and updated the search on February 1st 2022. Included studies were cross-referenced to identify additional studies.

Data Extraction and Analysis

One reviewer (HG) removed duplicates and led the process of study screening and selection. Study selection was managed using the online reference manager Rayyan.[19] The search results were reviewed on two sequential levels. In the initial "title and abstract stage", the article titles and abstracts were screened according to the inclusion and exclusion criteria independently by two researchers (HG and TF). The lists of included studies and summaries of the collected data constructed by the two researchers were compared. Any disagreements were resolved by discussion and involvement of a third researcher (DvD). In the second "full-text stage", the remaining articles were examined to ensure that they met the inclusion criteria.

Study characteristics were systematically extracted using a structured data collection form that included the following parameters: type of telemonitoring, study location, year of publication, research methods, patient characteristics, and outcome measures of adoption. The charted data was verified by a second reviewer (TF or DvD).

Interpretation and analysis using Mendel's framework

In addition to the extraction of study characteristics, text components from the included articles, relevant to the nationwide implementation of telemonitoring, were extracted by one of the researchers (HG). The extracted text components were uploaded into a qualitative analysis software program (MAXQDA Analytics Pro, VERBI Software, 2020), and coded to capture all relevant constructs. A second researcher encoded independently of the first researcher 25% of the articles, after which they verified their coding. If there were significant differences between the first and second researcher, the differences were discussed and the procedure repeated.

The structure of the analysis was based on Mendel's framework for Building Evidence on Dissemination and Implementation in Health Services Research[20] (appendix 3). This framework supports the understanding and assessing of relevant contextual factors and dynamics affecting the dissemination, implementation, and sustainability of interventions within communities and healthcare settings. In this scoping review, the "diffusion process" items of Mendel's framework were used to better understand and generalise the relevant contextual factors from different studies involved with nationwide upscaling of telemonitoring.

Results

The search yielded 2927 records. After the removal of duplicates, 2298 titles and abstracts were screened for inclusion and exclusion. 2250 studies were excluded after title and abstract screening, leaving 48 articles for full-text screening. All numbers were used to create a flowchart (Figure 1). Additional details for the reasons of exclusion are presented in Table 1. Finally, a total of 19 articles were included for analysis, describing a variety of telemonitoring solutions.[21-38]

Characteristics of studies

The general characteristics of the included studies are presented in Table 2. Eleven out of 19 articles described a survey[21 22 25 28-30 33 34 36-38], four described focus group interviews[27 31 35 39], three articles were narrative reviews[24 26 32], and one article described the results of a workshop.[40] A total of 89 enabler or barrier factors were mentioned 202 times in 19 studies.

Scale and utilisation of telemonitoring

The utilisation of telemonitoring was reported in 13 of the 19 studies. Reported utilisation varied widely from “not part of routine care, or not available as standard care” in Austria , Norway, Lithuania, the UK and Sweden, to “90% utilisation of tele-electrocardiography” in Brazil.[21 22 28 33 35]

There was significant heterogeneity of the definition of utilisation, which was reported as: number of patients that used telemonitoring[32 36 37 39], percentages of actual use[29], number of clinics that are engaged in telemonitoring[24 36 37], number of hospitals offering telemonitoring for high-risk pregnancies[38], number of projects in a country[30] and total recorded measurements.[37]

The percentages of the actual use of telemonitoring in patients with heart failure varied from 3% to 77%.[25 29 37] In Brazil, a telemonitoring system for the monitoring of heart rhythms with an electrocardiogram was implemented in 79 municipalities. This study showed a utilisation ratio higher than 90%. [22] In Denmark, all telemedicine projects are mapped to provide a national contemporary overview of telemedicine initiatives. Utilisation is reported by referring to a website on which 16 active telemonitoring projects are registered within the country at this moment.[30 41] The enablers and barriers for nationwide upscaling of telemonitoring were structured in three domains using Mendel’s framework: context of diffusion, stages of diffusion and intervention outcomes.

What are the enablers and/or barriers for upscaling of telemonitoring?

Regarding the context of diffusion, the enablers and barriers retrieved were classified into six different categories of contextual factors: being an enabler, a barrier, or both according to Mendel's framework (Figure 2). Table 3 gives an overview of factors and supplementary table 1 describes barriers and/or enablers in more detail.

1. *Norms & Attitudes.*

Primary physicians needed to adapt their standard procedures in order to make an efficient contribution to care using telemonitoring solutions, for example by using the patients' self-measurements instead of doctor's office in-house measurements.[27] Healthcare professionals or centres that are aware of the benefits have a more positive attitude regarding telemonitoring.[29 31 37] In two studies, healthcare professionals had high expectations of working with telemonitoring, as well as managing caseloads more efficiently.[35 36]

A common perceived barrier for professionals is that telehealth can increase workload and make planning work more difficult when responding to monitoring alerts.[35] Across different studies professionals shared the view that patients may become too dependent on the technology making it a clear barrier for the use of telemonitoring.[27 31] Some studies report scepticism or reservations concerning telemonitoring.[21 31 35]

Another important barrier for the diffusion of telemonitoring is the lack of awareness of the possibilities and opportunities for providing care using remote monitoring among both health care management and clinical staff.[40]

2. Organisational Structure & Process.

Eleven studies reported on organisational items.[21 24-28 32 35-37 40] Adoption of telemonitoring requires an infrastructural investment that will take several years to implement and will involve a complete overhaul of existing practice, clinically, financially, and managerially.[40] An elaborate program of change management is described as an enabler in the upscaling and implementation of telemonitoring.[24 40] Change management is described as continuous evaluation and assessment in the refining of patient selection criteria for remote monitoring, and personalising care pathways.[24] Security and privacy aspects influence implementation.[21 24 28 32 37] Setting up appropriate vendor agreements and protocols is described as an enabler concerning responsibility for incoming data.[21 24 28 35 36 40]

3. Resources.

Financial aspects of telemonitoring are described as an important factor in nine studies.[21 24-26 28 35-37 40] For example, a lack of financial resources is described as among the four most important barriers for the adoption of eHealth.[25] Six studies described reimbursement as a barrier for implementation of telemonitoring.[21 24 26 28 33 40] According to these studies a suitable reimbursement solution should be adopted to incentivise and engage all stakeholders and to drive the intended transformation of healthcare delivery. Along with the financial aspects, concern rises for the possible inability to access the telemonitoring system via the electronic medical records.[27 32 35 37 40] Also, a lack of interoperability generates new tasks to share telehealth data with other clinicians via electronic patient records. This also causes concerns whether the telehealth data entered in a patient's record are accurate and relevant. This makes interoperability standards crucial to the success of upscaling remote patient monitoring programs.[32 40]

4. Policies & Incentives.

Three studies indicate that policies governing telehealth may differ at the state level, which forms a barrier for implementation on interstate level.[26 35 40] On a national level, professional societies can issue guidelines to enable telemonitoring.[22 24] European and worldwide policies on innovation friendly, legal and regulatory frameworks may enable upscaling of telemonitoring.[24 26 40]

5. Networks & Linkages.

Four studies described non-profit or public-private collaborations as enablers for implementation of telemonitoring.[24 26 28 32]. For example, a role for professional organisations like the European Society of Cardiology (ESC) in collaboration with national societies is described in catalysing reimbursement and adoption of telemonitoring in cardiac diseases.[24] A national repository could act as the first port of call where policy makers, clinicians, and users could access information of remote monitoring projects.[40] Another approach could be an extended partnership between device companies and health care systems involving telemonitoring services.[26]

At a regional level, collaborative efforts may connect hospital and regional health executives to network leaders, focusing on adoption, scale, and spread of network monitoring solutions. Collaboration between hospitals and primary care providers, within the Ontario Telemedicine Network, proved to be an important factor for the sustainability of a tele homecare program in Canada.[28 32]

6. Media & Change Agents.

Two studies described media and change agents as enablers for the implementation of telemonitoring. Advocates, early adopters and local champions are described as an important source of information and advice for the introduction of telemonitoring.[24 35 37]

Stages of diffusion

Enablers and barriers were reported not to be linked to an implementation stage nor to a specific stage of diffusion. However, based on the reported utilisation and phase of upscaling, it is possible to analyse what stage of diffusion a telemonitoring project is most likely to be in. Eight studies described telemonitoring in the stage of pre adoption. [21 25-28 33 35 36] Six studies described telemonitoring in the implementation stage. [24 31 32 37 39] Only two studies described telemonitoring projects in the phase of sustainment. [22 32] In three studies it was not possible to analyse the stage of diffusion.

Intervention outcomes

Enablers and barriers for implementation may affect outcomes for individuals in the community, as well as local organisations and systems of care. All the expected outcomes for implementation of telemonitoring are described in table 4.

Patient Care & Health Outcomes. Six studies reported outcomes on an individual level and in what way they were expected to be affected by telemonitoring. For example, implementation of telemonitoring was expected to improve self-care or patient empowerment. [21 24 27 28 36 40]

Organisation & System Outcomes.

Five studies reported on the expected outcomes on an organisational and system level. For example, when telemonitoring was implemented, it was expected that more patients could be treated, which would reduce admission and visits [21 24 28 33 40], workload would be reduced [21 28 33] and costs would be reduced.[21 24 28]

Discussion

This scoping review provides insight into the enablers and/or barriers that affect upscaling of telemonitoring in healthcare across different settings. All included studies examined large scale adoption or implementation of telemonitoring. One study described an International and European scale up.[37] This review retrieves and identifies important overarching factors, relevant for nationwide upscaling.

One of the most frequently mentioned factors of influence is “costs” or “reimbursement”. For example; providing an eHealth infrastructure for free throughout the project duration is a great enabler.[37] Reimbursement is mentioned as a solution - “a suitable reimbursement solution should be adopted”[24] – or as a barrier: “there is no financial backing to adopt new systems such as remote monitoring”.[40] Economic evaluations of eHealth applications are gaining momentum, and studies have shown considerable variation regarding the costs and benefits that they include.[42] Economic studies on telemonitoring in heart failure and women at risk of preeclampsia describe this duality. The initial cost of the telemonitoring equipment may be an obstacle to widespread use of telemonitoring. Although telemonitoring will require an initial financial investment, economic studies show substantially reduction of costs in the long term.[43 44] Costs, as a factor of influence, exist in coherence of “a lack of evidence”. In the absence of solid empirical evidence, key decision makers may doubt the effectiveness of eHealth, which, in turn, limits investment and its long-term integration into the mainstream health care system.[45] Exploring alternative payment models, for example “temporary” funding of telemonitoring by health insurers, could bridge that gap so that the necessary evidence can be collected.

Over half of the factors identified are stated both as an enabler and a barrier. Therefore, factors of influence found in this scoping review can be used pragmatically; e.g. as a directive to check whether the factor is a barrier or an enabler in projects where upscaling is required. A relatively large number of factors are related to the “norms & attitudes” of users. Although this is an important factor for local implementation, one would expect that proportionately more context-related factors for nationwide scaling up would be found. Resources, attitudes, intrinsic motivation and behaviour of end-users, costs and technical knowledge of health care providers are all important factors of influence. These findings are consistent with reviews on implementation of other types of eHealth or telemedicine.[13 46-49]

The utilisation and upscaling of telemonitoring varied widely across settings and was not reported in 30% of the included studies. Because adoption is not clearly defined in the studies it is not possible to interpret the enablers and barriers for each phase of adoption. In future studies, it is recommended to give a clear definition of adoption and to report utilisation. Only then is it possible to learn more about barriers and facilitators in various stages of implementation to scale up.

Studies in this scoping review reported expected “patient care & health outcomes”. Outcomes were not correlated to certain enablers or barriers. Based on this scoping review it is not possible to draw

conclusions regarding factors of upscaling influence the outcomes of care, nor which outcomes of care influence the upscaling. Although it would be useful to know more about upscaling of telemonitoring in relation to specific patients conditions, this study focused on the possible facilitators and barriers for (nation)wide upscaling regardless of patient conditions.

An untouched topic in this scoping review is the potential change in health (in)equity created or perpetuated by the scale-up of telemonitoring projects. After all, those without access to the technology and/or infrastructure necessary for successful telehealth may be left out of any scale-up efforts. A retrospective cohort during the Covid-19 pandemic shows that inequities in telehealth utilization persist and require ongoing monitoring.[50] In this review, lack of resources and infrastructure are key factors that not only impede scale-up, but can also cause health inequities. Information and education strategies appear to be important enablers for scale-up, but they are also successful strategies for reducing health inequities.

Practical implications

Based on the findings in this study, a coordinated and structured collaborative approach enables the upscaling of telemonitoring, embodying:

A wide program on change management, including policies and protocols on adaption of healthcare processes; Implementation coordinators, who set up requirement specifications with particular attention to interoperability standards, telemonitoring access to electronic medical records, security and privacy aspects, and appropriate vendor agreements; Widespread marketing and recruitment initiatives, for example social media channels that enable the recruitment of participating centres; Collaboration among different hospitals and between primary care and hospitals, as a way to overcome organisational and regional differences and to create an economy of scale, and;

New and innovative ways for reimbursement.

There was disagreement during the selection of studies that required discussion with a third reviewer. There are studies in which blood pressure is measured automatically at home. However, the data of these measurements were not exchanged electronically with the hospital in these studies. Studies investigating this form of home measurement have not been included in this scoping review. Narrowing down the definition of telemonitoring in the search is an important strength of study. A range of terms like “remote monitoring”, “teleconsultation”, “telehealth” or “telecare” is used interchangeably in the definition of telemonitoring. There are 23 different exclusion reasons for 2015 exclusions due to the terminology of telemonitoring. (Table 1). For example; teleconsultation, video-consultation and remote monitoring by telephone calls are all described as telemonitoring and

355 studies used “telemonitoring” as a keyword for a mobile health application without telemonitoring functionality. Using this precise definition of telemonitoring makes it possible to compare the results of this study with future studies on upscaling telemonitoring. Another strength of this study is the use of Mendel’s framework, which provided to be fit for categorizing the scoping review results on upscaling of telemonitoring across the included studies.

This review analysed search results from four well-known research databases. It uses key terms registered with MeSH, and multiple reviewers determined the inclusion and exclusion criteria. A limitation to this study could be the coding of extracted text components by the second reviewer, who coded only a purposeful sample of all studies. However, no significant differences were identified between the first and second reviewer, therefore it is unlikely that this resulted in bias.

Due to the large amount of heterogeneity in the included studies with regard to study design, types of telemonitoring, and measurement of adoption or utilisation, advice on how to scale up a telemonitoring project within countries has to be made carefully. For future research it is desirable to use a clear and narrow definition of telemonitoring, utilisation and outcome measures.

Conclusion and recommendations

We live in a world where telemonitoring rapidly integrates into preventive and clinical care and well-being. Successful upscaling of telemonitoring requires insight into the factors of influence in adoption, especially at an overarching national level. To futureproof and facilitate upscaling of telemonitoring it is recommended to find means for reimbursement to use this type of technology in usual care and to explore alternative payment models early on. A wide program on change management, national or regional coordinated, is key. Clear regulatory conditions and professional guidelines may further facilitate widespread adoption and use of telemonitoring. The results of this study can be used to help develop a guideline for upscaling.

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authors have read and approved the final paper and agree to be accountable for all aspects of the work.

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Figure legends

Figure 1. PRISMA flowchart showing the process of including and excluding studies.

Figure 2. The number of enablers, barriers, or both regarding the context of diffusion according to Mendel's framework.

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Table 1 Reasons for exclusion.

# excluded		Reasons
2279	2015	Not describing telemonitoring as defined in the inclusion criteria; but described 569 teleconsultation 355 mHealth applications (without telemonitoring functionality) 251 health informatics topic in general 126 implementation of an EHR 105 e-mental health 61 lifestyle promotion 44 internet based therapy 23 tele-dermatology 22 tele-rehabilitation 19 e-prescription 18 addiction related 15 related to systems and technology 12 tele-ICU 12 smart home (care) 10 teledentistry 9 AI related 9 tele-ophtalmology 5 e-registries 5 teleradiology 5 blockchain 3 background articles 2 teleaudiology, 2 internet of things, 2 robotics, 1 RFID, 1 AR/VR 325 excluded for not describing telemonitoring with other reasons
	146	articles described a telemonitoring or eHealth project, without describing implementation or adoption.
	57	Articles described telemonitoring implementation, but not in more than one independent organisation or setting and across geographical boundaries.
	26	study protocol
	24	opinion papers or interviews
	15	non-English

EHR = Electronic Health Record, mHealth = mobile Health, RFID = Radio-frequency identification, tele-ICU = tele intensive care unit, AI = artificial intelligence, AR/VR = augmented reality / virtual reality.

Table 2 Study characteristics

#	Study and year	Country	Design	Condition	Type of telemonitoring	Analysis	Outcome measures for adoption
1	Aamodt 2019[21]	Norway and Lithuania	Cross-sectional survey	Heart failure care	Body weight, blood pressure, heart rate, dyspnea	Summative content analysis	Reported as not part of routine care / standard care
2	Alkmim 2019 [22]	Brazil	Survey	Cardiology	Tele-ECG	Descriptive statistics	Utilisation>3days per week
3	Chronaki 2013 [24]	Europe	Narrative review	Diverse	Tele-ECG	N.a.	Health care costs + number of clinics engaging in TM
4	Cook 2016 [39]	UK	Qualitative semi-structured interviews	COPD	Telehealth: Pulse oximetry, temperature, pulse, blood pressure	Framework method	N.a.
5	Diaz-Skeete[40]	Republic of Ireland	Workshop report	Cardiac care	n.a.	n.a.	n.a.
6	Faber, 2017 [25]	Netherlands	Survey	Heart failure + diabetes	N.a.	Structured equation modelling approach	Extent of adoption in percentages
7	Fraiche 2017 [26]	US	Narrative review	Heart failure	Blood pressure, weight, ECG	N.a.	N.a.
8	Hanley 2018 [27]	Scotland	Qualitative interview + focus groups	COPD, hypertension, BP after stroke, COPD, heart failure, diabetes	SpO2, BP, blood glucose,	Interpretive description approach and thematic analysis	N.a.
9	Kato 2015 [28]	Japan and Sweden	Cross-sectional survey	Heart failure	Monitoring physical condition and noticing a decline	Descriptive analysis and content analysis methodology	4 domains Reported as not part of routine care
10	Klack, 2013 [29]	Germany	Survey	Heart patient	weight, temperature, blood pressure, coagulation	Descriptive statistics	Physician and engineers perspectives Extent of adoption in percentages
11	Kristensen 2019 [30]	Denmark	Email survey	Chronic heart failure, atrial	Blood pressure, heart rhythm,	Number of initiatives in	Number of projects

				fibrillation, COPD, ADHD, Pregnant with complications, hypertension, patients with an ICD	body weight, heart rate, blood glucose,	interactive map online	registered.
12	MacNeill, 2014 [31]	UK	Semi structured qualitative interviews	Chronic heart disease, COPD and diabetes	Blood pressure, weight, oxygen, blood glucose	Modified grounded theory	
13	McGillion 2018 [32]	Canada	Narrative review	Surgical population	Respiratory rate, blood pressure, heart rate, SpO2, temperature	N.a.	N.a.
14	Muigg, 2019 [33]	Austria	Cross-sectional survey	Diabetes	Blood pressure and blood glucose	Qualitative content analysis	Reported as not part of routine care
15	Okazaki, 2013 [34]	Japan and Spain	Survey	Not specified	Not specified	Causal modeling	n.a.
16	Taylor, 2014 [35]	UK	Qualitative interviews	COPD and Chronic heart failure	Not specified	Thematic analysis	n.a.
17	de Vries, 2013 [36]	Netherlands	Survey	Heart failure	Blood pressure, weight, heart frequency, ECG	Descriptive statistics	Usage
18	Van den Heuvel[38] 2020	Netherlands	Survey	Women with pregnancy complications	Cardiotocography	Descriptive statistics	Provision of telemonitoring and perspectives of respondents
19	Gawalko[37] 2021	Europe	Survey	Management of atrial fibrillation	Remote PPG or 1-lead ECG	Descriptive statistics	Centre experience and patient experience.

n.a. = not available

Table 3. An overview of factors, classified by the "diffusion process" items of Mendel's framework

	#Factors	#Described	#Barriers	#Enablers	#Both
1. Norms & Attitudes	31	51	12	10	9
2. Structure & Process	16	33	3	3	10
3. Resources	19	75	2	2	15
4. Policies & Incentives	10	23	0	1	9
5. Networks & Linkages	3	8	1	1	1
6. Media & Change agents	10	12	0	9	1
Total	**89**	**202**	**18**	**26**	**45**

The number of times factors of influence were described in total; and the number of times factors were described as barrier, enabler or both.

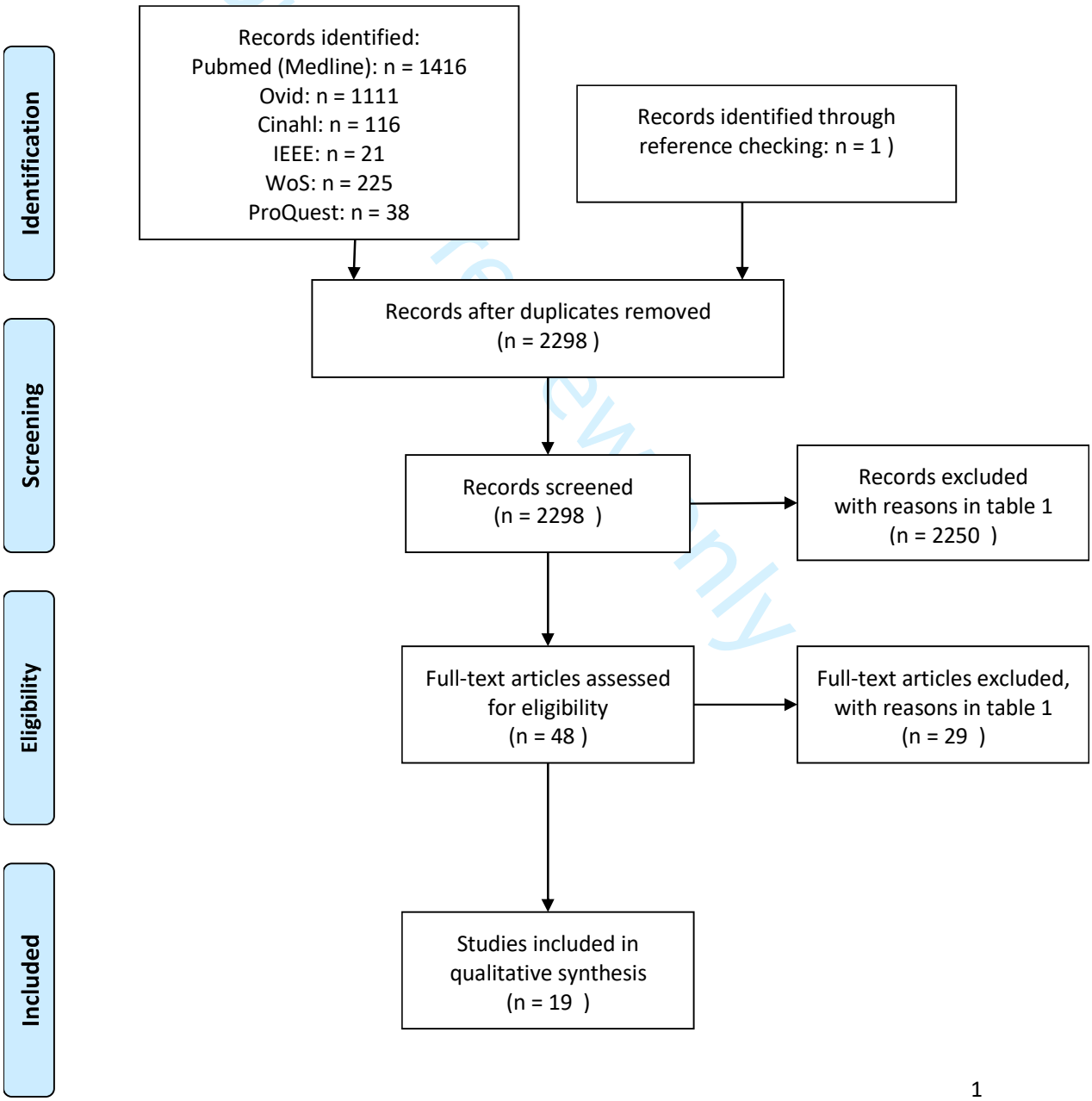
Table 4. The (expected) intervention outcomes when telemonitoring is implemented.

Domain	Contextual factors	Detailed description	Number of publications mentioned
Intervention outcomes	Patient care & health outcomes	(improve) self-care or patient empowerment [21 24 27 28 36 40]	6
		(improve) quality of care [21 28 33 36 40]	4
		(improve) patient education [21 28 36]	3
		(improve) symptoms of disease [28 36]	2
		(improve) quality of life [24]	1
	Organisation & System outcomes	Treat more patients (and reduce admission and visits) [21 24 28 33 36 40]	5
		(reduce) workload [21 28 33 36]	4
		(reduce) costs [21 24 28]	3
		(improve) adherence to guidelines [21 36]	2
		Contribute to continuity of care [24]	1

Figure 1 PRISMA flowchart showing the process of including and excluding studies.

Search syntax:

("Telemedicine"[Mesh] OR telemedicine[tiab] OR mhealth[tiab] OR m-health[tiab] OR ehealth[tiab] OR e-health[tiab] OR out-of-office[tiab])
AND
("Monitoring, Physiologic"[Mesh] OR "Monitoring, Ambulatory"[Mesh] OR monitor*[tiab] OR telemonitor*[tiab] OR health care[tiab] OR healthcare[tiab])
AND
("Implementation Science"[Mesh] OR "Health Plan Implementation"[Mesh]
AND
scale up[tiab] OR implement*[tiab] OR adoption[tiab])
AND
("Health Policy"[Mesh] OR "Policy Making"[Mesh] OR "National Health Program "[Mesh] OR policy[tiab] OR survey*[tiab] OR mapping[tiab])



Number of factors that influence upscaling

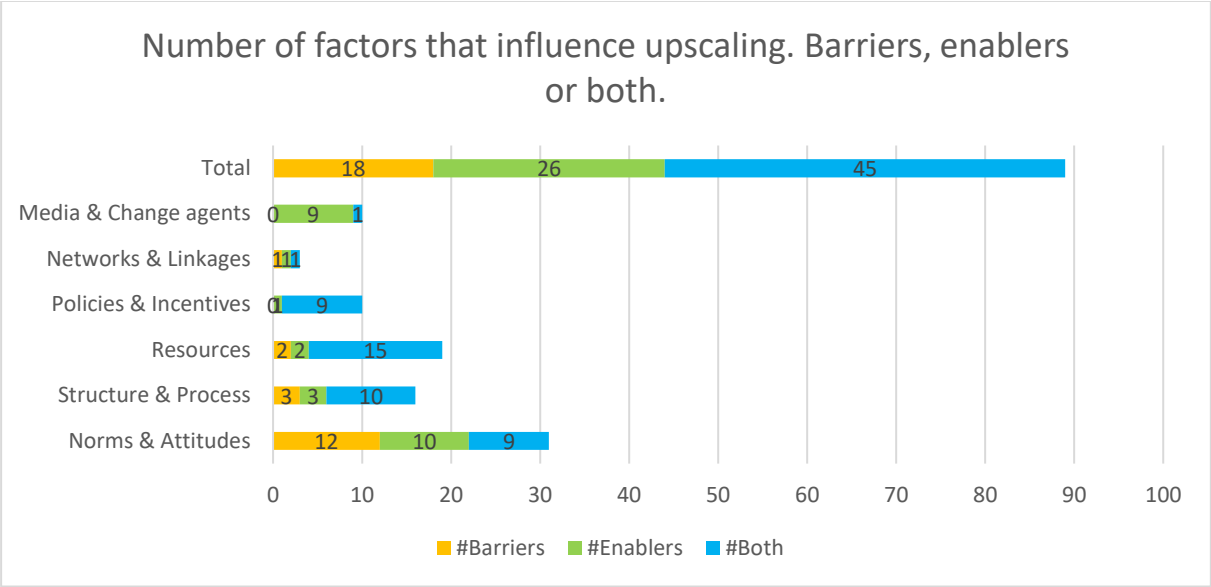


Figure 2. The number of enablers, barriers, or both regarding the context of diffusion according to Mendel's framework.

Supplementary Table 1. Overview of factors – enablers and/or barriers – that influence nationwide upscaling of telemonitoring.

Domain	Contextual factors	Detailed description	Barrier, Enabler or Both	Number of times mentioned in publications
Context of diffusion	Norms & Attitudes	HCP think that patients become too dependent on technology[27 31 39]	Barrier	4
		HCP have scepticism or reservations about TM[28 31 35]	Barrier	3
		There must be a perceived usefulness and usability of equipment [27 31 39]	Both	3
		TM is convenient for patients [27 31 37]	Enabler	3
		HCP have a positive attitude (towards usefulness, feasibility, potential) [29 31 37]	Enabler	3
		There is concern amongst HCP that acting on the TM data provided could lead to overtreatment[27 31]	Barrier	2
		HCP consider use of TM relevant [21 28]	Enabler	2
		HCP have high expectations of working with TM[36]	Both	2
		TM makes patients anxious [27 31]	Barrier	2
		HCP think that TM can increase workload and make planning more difficult[35 36]	Barrier	2
		Make patients feel more empowered to take a pro-active approach to their health[27] or should be empowered to engage with technologies for selfmanagement and self-care purposes[40]	Enabler	2
		HCP perceive a shift to technology making medical decisions or support in medical decision making[29 37]	Both	2
		Although the HCP had high perceptions and expectations of working with TM, these were not positively reflected in the actual experiences.[36]	Barrier	1
		HCP expect to manage caseload more efficiently[35]	Enabler	1
		Change personal practice[27]	Both	1
		Concerns about the impact of telehealth on nursing roles[35]	Barrier	1
		HCP experience a lack of advantage[28]	Barrier	1

		HCP who have the knowledge and experience in TM, tend to have a less positive attitude compared with technical professionals, who might be driven by their greater enthusiasm for technology in general.[29]	Both	1
		HCP think that TM is more expensive than conventional treatment[29]	Barrier	1
		Technical professionals are more confident about patient compliance then HCP [29]	Both	1
		HCP concern about privacy protection[29]	Barrier	1

		HCP concern about the loss of control over the medical treatment[29]	Barrier	1
		HCP think that patient acceptance is a factor of influence[37]	Both	1
		Use of telehealth is an important new skill for HCP, as was the ability to understand trends in the management of long-term conditions[31]	Enabler	1
		HCP see TM as an opportunity for professional career development[31]	Enabler	1
		HCP consider "Our centre is innovative" [21]	Enabler	1
		Patients need to accept their old age and health condition, before they use TM [39]	Both	1
		Reducing the level of face-to-face contact with the patients was a concern for professionals, but this concern was not universally shared by patients, some of whom experienced the non-face-to-face contact as additional and efficient input.[27]	Enabler	1
		HCP have concerns about the appropriateness of telehealth for the very severely ill[31]	Barrier	1
		Early positive experiences and the sharing of success were identified as key enablers for staff acceptance. Early negative experiences of telehealth have a long-lasting impact on staff acceptance and the predominant view among participants[35]	Both	1
		HCP state that telemonitoring provides higher patient satisfaction (related to home-monitoring) and does not require hospital staff to visit patients at home [38]	Enabler	1
	Organisational structure & process	Security and privacy aspects that influence implementation [21 24 28 32 38 40]	Both	6
		Rules and protocols on the implementation of the system and responsibility for incoming data[21 28 35 36 40]	Both	5
		Certain processes / coordination support implementation of TM [28 32 35 36]	Both	4

		Use of TM enables clinical decision support and influence adoption of guidelines [24 26 27]	Enabler	3
		Regular data sharing had a motivating effect on patients, as they were aware that at some point the readings may be reviewed [27] or is a possible limitation[40]	Both	2
		A wide program of change management to support healthcare transformation and adoption of new working practices [24 40]	Both	2
		Reduce admissions or readmissions [21 36]	Enabler	2
		Creating central databases making the transmitted data accessible to the treating physician and serving as data registries that benefit medical research [24]	Enabler	1
		Set up appropriate vendor agreements and infrastructure [24]	Both	1
		Protocols on the acceptable length of time between the moment of incoming patient data and the response of the HCP(response-reaction time) [36]	Both	1
		Difficult to obtain relevant data about patients and ensuring that relevant data –	Barrier	1

		limited tailoring to individual patient - is shared with HCP [35]		
		Limited options for discharging patients who will benefit from continued use [35]	Barrier	1
		Referral routes should be opened up for patients with other conditions and with less complex needs [35]	Both	1
		A changing environment is a barrier [35]	Barrier	1
		The introduction (the way of communication, red.) to frontline staff influences implementation [35]	Both	1
		Organisational size influences implementation of TM [25]	Both	1
	Resources	Costs / financing of TM [21 24-26 28 35-38]	Both	9
		Knowledge of HCP / training of frontline staff [21 24 28 32 35-37 40]	Both	8
		Reimbursement as an element of financial resources[21 24 26 28 33 37 38 40]	Both	8
		The TM-system access to the EMR / interfacing of technologies [24 26 27 32 35 37]	Both	6
		Design of telemonitoring system / usability [26 27 32 37 39 40]	Both	6
		Availability of equipment [21 28 35 37]	Both	5
		Sufficient staffing [26 28 32 37 40]	Both	5

		Time for implementation TM [27 32 35]	Both	5
		Lack of evidence for TM [21 24 26 40]	Both	4
		Engage stakeholders in system design [32 35 40]	Both	4
		(Lack of)Cloud acces, internet access or cellular access [28 32 37]	Both	3
		Organisational readiness [25 33]	Both	2
		Significant income disparities which impact the ability to enforce guidelines and advance adoption of TM [24]	Barrier	2
		An externally resourced system for installation, technical support, maintenance and de-installation [35 37]	Both	2
		Local “champions” [35]	Both	1
		Top management support [25 40]	Both	1
		Staff to assume monitoring and management responsibilities for patients outside the hospital [26]	Both	1
		On-boarding process to a TM project. [37]	Both	1
		(Patient)education to address concerns regarding the use of remote monitoring , specifically for older adults, as an enabler [40]	Enabler	1
		Assessment of added value should be calculated [38]	Enabler	1
	Policies & Incentives	Addressing security, social and ethical issues to enable implementation of TM [24 28 32 37 38]	Both	5
		A (lack of) vision of an organisation on implementing TM [21 28 35]	Both	3
		Worldwide, European and statelevel policies and legal and regulatory frameworks [24 26 40]	Both	3
		New or adjusted workflows, care paths or data management [24 27 37]	Both	3
		Consensus statements and national guidelines [22 24]	Both	2
		Reimbursement or alternative payment models as a financial incentive for organisations [24 26]	Both	2
		Target patients, volume of population, data load and work intensity within organisations [28 35 37]	Both	3
		Interoperability standards crucial to the success of scaling remote patient monitoring programs [32]	Both	1

		Policy and practice developments affecting health care services [35]	Both	1
		Importance of TM for health authorities [21]	Enabler	1
	Networks & Linkages	Collaboration non-profit or public-private organisations [22 24 26 35 40]	Both	5
		Not being able to collaborate with other hospitals or clinics and primary care providers [28 32]	Barrier	2
		Professional organisations in collaboration with national societies can play an important role in catalysing reimbursement and adoption [24]	Enabler	1
	Media & Change Agents	Advocates, early adopters and local champions enable implementation of TM [24 35]	Enabler	2
		Create (and increase) awareness in the general clinical community of the potential that remote monitoring has [37 40]	Enabler	2
		A standardized initiation video call to inform and instruct each participating centre[37]	Enabler	1
		(Lack of) guidelines from health care authorities [21]	Both	1
		Device manufacturer that invest in TM [24]	Enabler	1
		The dynamics in the COVID-19 pandemic may have impacted the use of TM[37]	Enabler	1
		Consensus on the implementation and research agenda can pave the road to the widespread use of digital health services[38]	Enabler	1
		A national repository could act as the first port of call where policy makers, clinicians and users could access information on remote monitoring projects[40]	Enabler	1
		Information about strategies to educate and empower patients were provided[37]	Enabler	1
		Professional societies can review and potentially endorse TM applications that offer valuable decision support and empower the physician's relationship to the patient [24]	Enabler	1

HCP= Health Care Professional, **TM**= Telemonitoring

Appendix 1. Preliminary search

Database	Search syntax	Results
Pubmed	("Telemedicine"[Mesh] OR telemedicine[tiab] OR mhealth[tiab] OR m-health[tiab] OR ehealth[tiab] OR e-health[tiab]) AND ("Monitoring, Physiologic"[Mesh] OR "Monitoring, Ambulatory"[Mesh] OR telemonitor*[tiab]) AND ("Implementation Science"[Mesh] OR "Health Plan Implementation"[Mesh] AND scale up[tiab] OR implement*[tiab] OR adoption[tiab])	723 of which 156 meta-analysis or reviews. None relevant for upscaling telemonitoring
JBI Evidence Synthesis	Telemonitoring AND Implementation	14 results, none relevant.
Open Science framework	Telemonitoring OR telemedicine	29 registries, none about upscaling
Prospero database	(telemonitoring [all fields] OR telemedicine [MeSH]) AND Implementation Science [MeSH] OR Regional Health Planning [MeSH] OR Health Plan Implementation [MeSH] OR Implementation [all fields]	102 results, none relevant for upscaling telemonitoring.

Appendix 2. Search syntax

Search syntax:

("Telemedicine"[Mesh] OR telemedicine[tiab] OR mhealth[tiab] OR m-health[tiab] OR ehealth[tiab] OR e-health[tiab] OR out-of-office[tiab])

AND

("Monitoring, Physiologic"[Mesh] OR "Monitoring, Ambulatory"[Mesh] OR monitor*[tiab] OR telemonitor*[tiab] OR health care[tiab] OR healthcare[tiab])

AND

("Implementation Science"[Mesh] OR "Health Plan Implementation"[Mesh]

AND

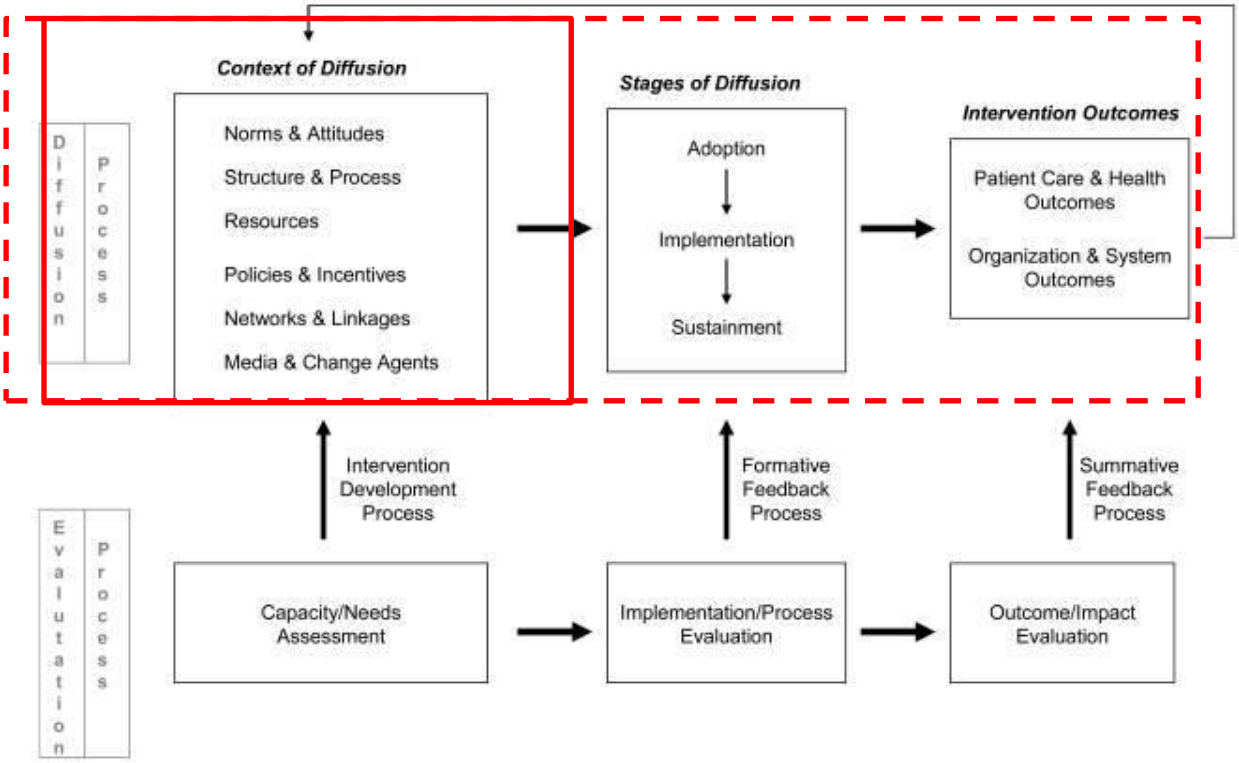
scale up[tiab] OR implement*[tiab] OR adoption[tiab])

AND

("Health Policy"[Mesh] OR "Policy Making"[Mesh] OR "National Health Program "[Mesh] OR policy[tiab] OR survey*[tiab] OR mapping[tiab])

Appendix 3

Framework of dissemination in health services intervention research. From: Mendel et al 2008, Adm Policy Ment Health (2008) 35:21–37. The red lined box indicates the focus in this scoping review.



Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR) Checklist

SECTION	ITEM	PRISMA-ScR CHECKLIST ITEM	REPORTED ON PAGE #
TITLE			
Title	1	Identify the report as a scoping review.	1
ABSTRACT			
Structured summary	2	Provide a structured summary that includes (as applicable): background, objectives, eligibility criteria, sources of evidence, charting methods, results, and conclusions that relate to the review questions and objectives.	2
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of what is already known. Explain why the review questions/objectives lend themselves to a scoping review approach.	4
Objectives	4	Provide an explicit statement of the questions and objectives being addressed with reference to their key elements (e.g., population or participants, concepts, and context) or other relevant key elements used to conceptualize the review questions and/or objectives.	4
METHODS			
Protocol and registration	5	Indicate whether a review protocol exists; state if and where it can be accessed (e.g., a Web address); and if available, provide registration information, including the registration number.	5
Eligibility criteria	6	Specify characteristics of the sources of evidence used as eligibility criteria (e.g., years considered, language, and publication status), and provide a rationale.	5
Information sources*	7	Describe all information sources in the search (e.g., databases with dates of coverage and contact with authors to identify additional sources), as well as the date the most recent search was executed.	5
Search	8	Present the full electronic search strategy for at least 1 database, including any limits used, such that it could be repeated.	Appendix 1 and appendix 2
Selection of sources of evidence†	9	State the process for selecting sources of evidence (i.e., screening and eligibility) included in the scoping review.	6
Data charting process‡	10	Describe the methods of charting data from the included sources of evidence (e.g., calibrated forms or forms that have been tested by the team before their use, and whether data charting was done independently or in duplicate) and any processes for obtaining and confirming data from investigators.	6
Data items	11	List and define all variables for which data were sought and any assumptions and simplifications made.	6
Critical appraisal of individual sources of evidence§	12	If done, provide a rationale for conducting a critical appraisal of included sources of evidence; describe the methods used and how this information was used in any data synthesis (if appropriate).	N/A
Synthesis of results	13	Describe the methods of handling and summarizing the data that were charted.	6

SECTION	ITEM	PRISMA-ScR CHECKLIST ITEM	REPORTED ON PAGE #
RESULTS			
Selection of sources of evidence	14	Give numbers of sources of evidence screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally using a flow diagram.	Page 7, figure 1 and table 1.
Characteristics of sources of evidence	15	For each source of evidence, present characteristics for which data were charted and provide the citations.	Page 7 and table 2
Critical appraisal within sources of evidence	16	If done, present data on critical appraisal of included sources of evidence (see item 12).	N/A
Results of individual sources of evidence	17	For each included source of evidence, present the relevant data that were charted that relate to the review questions and objectives.	Page 7 and 9, table 2, table 3 and table 4.
Synthesis of results	18	Summarize and/or present the charting results as they relate to the review questions and objectives.	Page 9, 10 and 11
DISCUSSION			
Summary of evidence	19	Summarize the main results (including an overview of concepts, themes, and types of evidence available), link to the review questions and objectives, and consider the relevance to key groups.	12, 13
Limitations	20	Discuss the limitations of the scoping review process.	14
Conclusions	21	Provide a general interpretation of the results with respect to the review questions and objectives, as well as potential implications and/or next steps.	14
FUNDING			
Funding	22	Describe sources of funding for the included sources of evidence, as well as sources of funding for the scoping review. Describe the role of the funders of the scoping review.	15

JBI = Joanna Briggs Institute; PRISMA-ScR = Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews.

* Where *sources of evidence* (see second footnote) are compiled from, such as bibliographic databases, social media platforms, and Web sites.

† A more inclusive/heterogeneous term used to account for the different types of evidence or data sources (e.g., quantitative and/or qualitative research, expert opinion, and policy documents) that may be eligible in a scoping review as opposed to only studies. This is not to be confused with *information sources* (see first footnote).

‡ The frameworks by Arksey and O'Malley (6) and Levac and colleagues (7) and the JBI guidance (4, 5) refer to the process of data extraction in a scoping review as data charting.

§ The process of systematically examining research evidence to assess its validity, results, and relevance before using it to inform a decision. This term is used for items 12 and 19 instead of "risk of bias" (which is more applicable to systematic reviews of interventions) to include and acknowledge the various sources of evidence that may be used in a scoping review (e.g., quantitative and/or qualitative research, expert opinion, and policy document).

From: Tricco AC, Lillie E, Zarin W, O'Brien KK, Colquhoun H, Levac D, et al. PRISMA Extension for Scoping Reviews (PRISMAScR): Checklist and Explanation. Ann Intern Med. 2018;169:467–473. doi: 10.7326/M18-0850.