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The Model for Assessment of Telemedicine (MAST): A scoping review of empirical studies

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Kristian Kidholm[1], Jane Clemensen[1], Liam J Caffery[2] and Anthony C Smith[2]

Abstract

The evaluation of telemedicine can be achieved using different evaluation models or theoretical frameworks. This paper presents a scoping review of published studies which have applied the Model for Assessment of Telemedicine (MAST). MAST includes pre-implementation assessment (e.g. by use of participatory design), followed by multidisciplinary assessment, including description of the patients and the application and assessment of safety, clinical effectiveness, patient perspectives, economic aspects organisational aspects and socio-cultural, legal and ethical aspects. Twenty-two studies met the inclusion criteria and were included in the review. In this article, research design and methods used in the multidisciplinary assessment are described, strengths and weaknesses are analysed, and recommendations for future research are presented.

Keywords

Research methods, research design, evaluation, frameworks, telehealth

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Introduction

Investment in telemedicine requires evidence to support the value and expected benefits from the perspective of the patient and health service provider. The evaluation of telemedicine can be achieved using a range of different evaluation models or theoretical frameworks.[1] Whilst these frameworks serve as useful guides, it seems that none have been used extensively.

The Model for Assessment of Telemedicine (MAST) is one evaluation framework which focuses on the measurement of effectiveness and quality of care. In this context, the MAST represents a multidisciplinary process, evaluating the medical, social, economic, and ethical aspects of telemedicine in a systematic, unbiased, robust manner.[2] This statement of principle is based on the definition of health technology assessment (HTA) in the EUnetHTA project.[3]

The use of MAST includes three steps as described in Figure 1. In the *preceding assessment* (Step 1) the maturity of the telemedicine technology and the organisation using the service is assessed before the assessment of effectiveness is carried out. If the maturity of the technology needs to be developed further formative studies including participatory design (PD) studies, usability studies or feasibility studies must be carried out. Similar optimisation studies can be used to mature and develop the organisation using the telemedicine service. Following implementation, a *multidisciplinary assessment* (Step 2) of the effectiveness of the technology can be carried out using MAST. MAST encompasses seven domains including identification of the health problem and characteristics of the application; safety; clinical effectiveness; patient perspectives; economic aspects; organisational aspects; and socio-cultural, ethical and legal aspects. Recently the face validity of the content of these seven domains has been confirmed in a Delphi process.[4] Finally, an assessment should be made of the *transferability of the results* (Step 3) reported in studies concerning the previous steps.

The aim of this paper is to review published studies which have used MAST for any of the seven domain areas. We have summarised the methods and research designs used for data collection, lessons learned, and considerations for further research. We hope that this information is useful for researchers and clinicians

[1]Centre for Innovative Medical Technology, Odense University Hospital, Denmark
[2]Centre for Online Health, The University of Queensland, Australia

Corresponding author:
Kristian Kidholm, Centre for Innovative Medical Technology, Odense University Hospital, Indgang 101, 5000 Odense C, Denmark.
Email: Kristian.kidholm@rsyd.dk

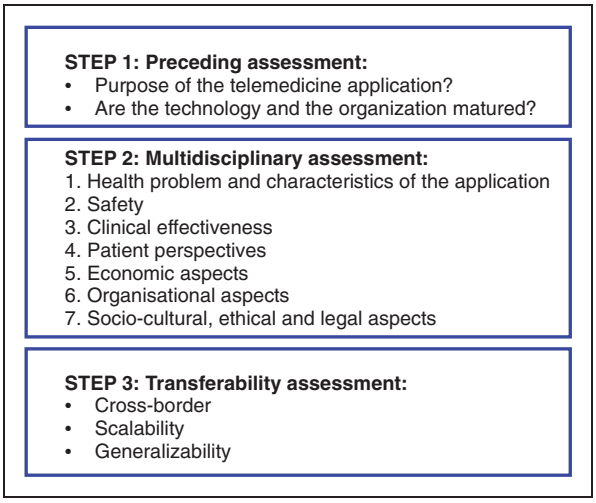

Figure 1. The three steps in Model for Assessment of Telemedicine.

planning to use MAST for the assessment of new telemedicine applications.

Methods

The scoping review was carried out using the Arksey and O'Malley framework.[5] Scoping review is a rapid form of knowledge synthesis where the aim is to map the key concepts underpinning a research area and the main sources of evidence available. It differs from a systematic review by addressing broader research questions, permitting inclusion of different study designs, not assessing the quality of the included studies, having a less structured data extraction, and typically using a qualitative synthesis of the evidence.[5] The scoping review included papers which explicitly reported on the use of MAST.

Research question

The research question in this review is: what are the lessons learned from the empirical studies of telemedicine based on MAST and which aspects require further research?

Eligibility criteria

We included studies that used the first step of MAST (i.e. the preceding assessment) or studies of the effectiveness and consequences of telemedicine (i.e. the multidisciplinary assessment). Studies were included if they described MAST as part of the basis for the design of the study of a telemedicine application. In addition, PD studies of telemedicine known to the authors are included because they form the basis for development of new types of telemedicine tested in ongoing studies based on MAST. Articles were included if they were published in the English language and in peer-reviewed journals from January 2013 to March 2017. Publications describing MAST as part of a description of research methods in telemedicine in general were excluded.

Search and screening

Relevant articles were identified by searching the Medline database and Google scholar using the search strategy: MAST AND (telemedicine OR telehealth OR ehealth OR mhealth).

Hereafter, citations of the first article describing MAST[2] in Medline and Google Scholar were reviewed. Initially, the titles and abstracts identified from the literature search were screened for empirical studies of telemedicine applications. The full text of the potentially relevant studies were obtained for assessment of eligibility and examined in order to identify descriptions of their use of MAST. This information is rarely available in the abstract and required careful examination of the full text. The search was done by the lead author and papers were subsequently reviewed by all investigators. Discussion amongst the authors led to the analysis of all papers identified in the search.

Data extraction

The following data were collected from the included studies: primary author, year of publication, country in which the study took place, intervention, patient group, study design, domains included and primary outcomes, protocol or reporting of results.

Analysis and reporting

We categorised the studies based on geographical distribution, the telemedicine interventions, and patient groups. Further, the study design and outcome measures including assessment of the clinical outcomes, patient perceptions, economic aspects, and organisational aspects were analysed, with a focus on the lessons learned and the need for additional research. The analysis and reporting focus on these four domains because they are most frequent in the studies of telemedicine based on MAST. Findings are reported narratively.

Results

The PubMed and Google Scholar search resulted in 10 and 1240 publications, respectively. In addition, 22 and 124 citations of the first description of MAST[2] were found in the two databases. Screening of abstracts and full-text articles resulted in 22 publications[6-27] being included in this review (Figure 2). A large number of citations of MAST were excluded because the articles were guidelines or reviews of the tool and models for evaluation, assessment or implementation of telemedicine and health information technology (IT), describing MAST as one of several models as an example.[28-30]

Studies were published between 2013 and 2017 and the telemedicine intervention took place in 12 European countries (Table 1). Most frequent are studies from Denmark (n=10) and Norway (n=7), reflecting that MAST was

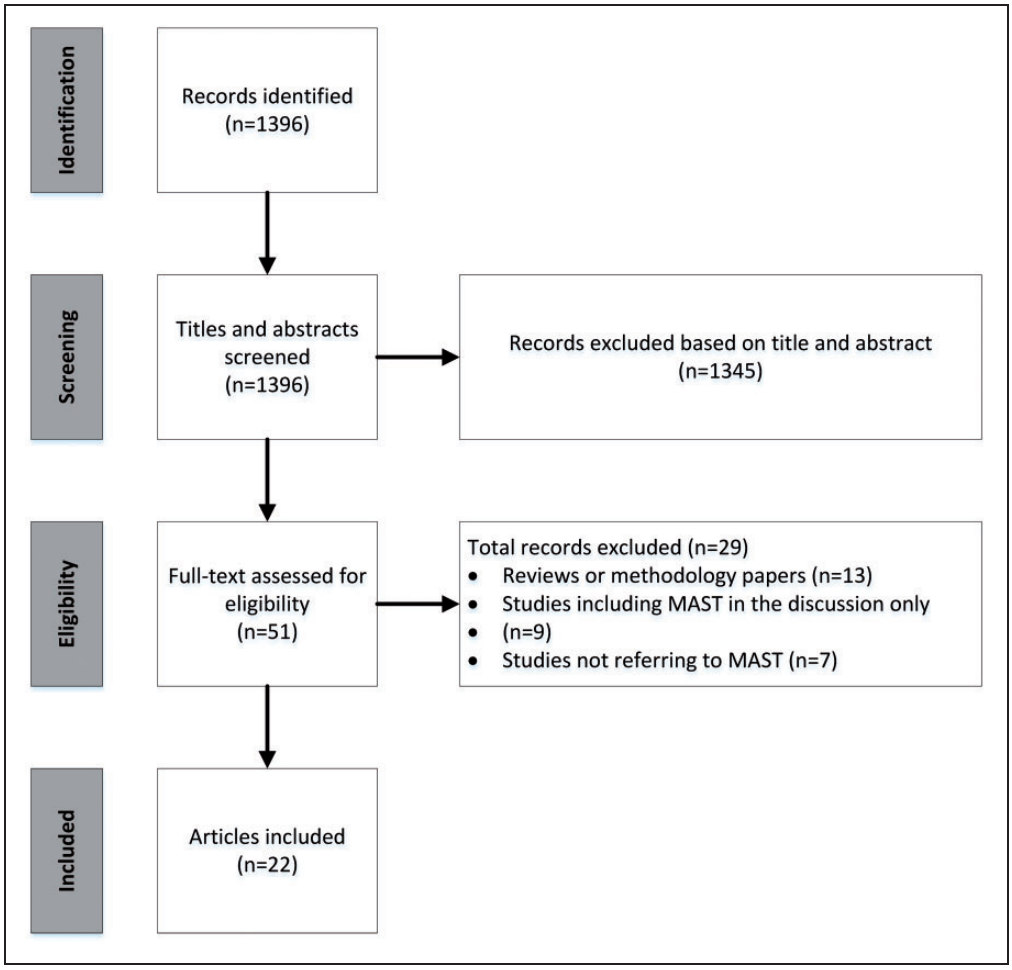

Figure 2. Flow diagram of search and screening of articles.

originally developed by researchers from Denmark, Norway, and Scotland. The majority (n=16) of the telemedicine interventions were home monitoring of patients with chronic disease (e.g. diabetes, chronic obstructive pulmonary disease (COPD) or heart disease). The remaining studies include patients with obesity, patients with limited access to care, parents using neonatal home care and support of early post-natal discharge. Thirteen studies are based on randomised controlled trials (RCTs), and other studies include observational studies, interview studies, pilot studies, and feasibility studies. Five publications describe protocols, the rest describe results from studies. Domains and outcomes measures included are described in detail below. A number of publications were based on the same study – for example, three publications described the clinical results,[22] the economic aspects,[13] and the organisational aspects[23] of telemedicine intervention for patients with diabetic foot ulcers. This study was also part of the European Renewing Health project and was similar to six other studies.[10,12,17,24-26]

Methods used in preceding assessment

One approach used for the development of new telemedicine interventions involves PD. Two examples are described in Table 1,[9,14] where PD was used in the development and design of interventions that were assessed by use of MAST. The use of PD in first step of MAST (the preceding assessment) has also been described.[4] The aim of PD is to develop technical systems in close and genuine cooperation with end users. An important requirement is not only to bring users into the laboratory setting, but also to bring researchers out into the field to observe, to ask questions, and to better understand the requirements.[31] PD is a multifaceted process, as the project can change continuously throughout the project period between analyses, design, and development.[32]

The research process starts in Phase 1 with a clinical or organisational problem you want to explore with identified stakeholders. The researchers then carry out a literature review and field studies. Getting a grip on problems and challenges, interviews and focus groups are performed to get the stakeholders' direct view. The next step includes user activities and creative workshops. The aim of the workshops is to reveal problems and visions about solutions in the focus area. In studies of telemedicine, the workshops have revealed new knowledge regarding the clinical problem that had not been captured by interviews and focus groups.[33,34] The next step is the development Phase 2, where the first prototype is developed, modified,

Table 1. Empirical studies of telemedicine based on MAST.

Primary author, year	Country	Intervention	Patient group	Study design	Domains included and primary outcomes	Protocol (P) or reporting of results (R)
Brandt, 2014	Denmark	Website with information and online communication with GP	Patients in need of weight loss	RCT	D3: Weight loss. D6: Organisation, communication, structure, perception	P
Cano, 2015	Greece, Norway, Spain	Integrated care services	Stable chronic patients, patients under Long-Term Oxygen Therapy, patients with COPD	2 RCTs 1 observational study, 1 cross sectional study	D2: Clinical and technical safety. D3: Saint George Respiratory Questionnaire. D4: User perspectives. D5: Cost-effectiveness. D6: organisational impact and incentives. D7: Regulatory issues, data privacy	R
Charrier, 2016	France	Tele-monitoring, tele-consulting or tele-expertise	Patients with long-term health conditions, patients with social or geographical limitation to care access	Two RCTs, Six before-after studies	D2: Safety. D3: Transport duration of specialist, hospitalisations, all-cause deaths, emergency department admissions, days of hospitalisation, time to perform diagnostic test, proportion of patients receiving dermatological expertise. D4: SUTAQ. D5: Cost-effectiveness. D6: Perception of professionals	P
Danbjørg, 2014	Denmark	Health app	Parents being discharged early postnatally	Participatory design study: Observational study and interview	D4: Perception of functionality of the app, the app in relation to their follow-up support needs, and communicating online. D6: Perception of nurses	R
Dario, 2016	Italy	Home monitoring	Diabetes, COPD and congestive heart failure	3 RCTs	D4: SUTAQ	R
Dario, 2016	Italy	Remote Monitoring of Pacemakers and Implantable Cardiac Defibrillators	Patients with pacemakers and implantable cardiac defibrillators	Observational study	D3: Admissions and outpatient visits. D5: Health care costs. D6: Workflow, workload, time spent by physicians and nurses	R
Dario, 2017	Italy	TM electronically transmitted glucose measurements to physicians	Patients with diabetes type 2	RCT	D3: SF-36, HbA1c, outpatient and ER visits, procedures with a diabetologist, hospitalisation rates, bed days of hospital care, Hospital Anxiety and Depression Scale (HADS)	R

(continued)

Table 1. Continued

Primary author, year	Country	Intervention	Patient group	Study design	Domains included and primary outcomes	Protocol (P) or reporting of results (R)
Fasterholdt, 2016	Denmark	Interactive wound platform consisting of a Web-based ulcer record combined with a mobile phone, enabling counselling and communication between nurses in the community and specialist health care	Patients with diabetic foot ulcers	RCT	D5: Cost-effectiveness	R
Garne, 2016	Denmark	Video-conferencing	Parents using neonatal home care	Participatory design study: Observational studies, individual interviews, and focus group interviews	D4: Parent experiences with neonatal homecare and home visits, including the meeting content and meaning	R
Hernandez, 2015	Greece, Norway, Spain	Integrated care services	Stable chronic patients, patients under Long-Term Oxygen Therapy, patients with COPD	2 RCTs 1 observational study, 1 cross sectional study	D2: Clinical and technical safety. D3: Saint George Respiratory Questionnaire. D4: User perspectives. D5: Cost-effectiveness. D6: Organisational impact and incentives. D7: Regulatory issues, data privacy	R
Iversen, 2016	Norway	interactive wound platform consisting of a Web-based ulcer record combined with a mobile phone, enabling counselling and communication between nurses in the community and specialist health care	Diabetes patients with foot ulcers	1 Cluster RCT	D3: Time of healing, time to amputation, mortality. D4: Patient experience. D6: Health care professionals experience	P
Karhula, 2015	Finland	Home monitoring and health coaching	Patients with diabetes and heart disease	RCT	D3: SF-36, glycosylated haemoglobin (HbA1c)	R
Lamprinos, 2016	Germany and Turkey	ICT-based self-management framework	Patients with diabetes	Pilot	D3: Blood sugar, physical activity. D4: SUS, TAM. D6: Usability, acceptance	R
Lewis, 2016	Scotland Wales Norway Spain	Home monitoring	Patients with COPD	Observational study	D3: Admissions D4: Patient perception D5: Costs per patient	R

(continued)

Table 1. Continued

Primary author, year	Country	Intervention	Patient group	Study design	Domains included and primary outcomes	Protocol (P) or reporting of results (R)
Minet, 2015	Denmark	Home tele-rehabilitation	Patients with COPD	Feasibility study	D2: Patient fall, emergency department visits. D3: Clinical COPD Questionnaire (CCQ), sit-to-stand test and a timed-up-and-go test. D4: Patient perception. D5: Business case. D6: Hospital staff perception	R
Petersen, 2015	Denmark	Intelligent bed	Patients with heart failure	Pilot study with observational study and interview with patients and staff	D4: Patient perception. D6: Perception of healthcare professionals. D7: Ethical concerns of patients	R
Rasmussen, 2015	Denmark	Interactive wound platform consisting of a Web-based ulcer record combined with mobile phone for communication between community nurses and hospital specialists	Patients with diabetic foot ulcers	RCT	D3: Hospital admissions, number of inpatient days related to ulcer treatment, surgical procedures, wound healing	R
Rasmussen, 2015	Denmark	Home monitoring	Diabetes patients with foot ulcers	Interview study with health professionals	D6: Perception of health professionals on impact on process, structure, culture, management	R
Ribu, 2013	Norway	Mobile phone-based diabetes diary, with and without health counselling and motivational interviewing	Patients with diabetes type 2	RCT	D3: Admissions, amputation, SF-36, behavioural change D4: SUS, SUTAQ D5: Cost-effectiveness D6: Staff perception of facilitators and obstacles	P
Sorknæs, 2013	Denmark	Home monitoring	Patients with COPD	RCT	D3: Number of hospital readmissions	R
Torbjørnsen, 2014	Norway	Few Touch Application diabetes diary with or without health counselling	Patients with diabetes type 2	RCT	D2: Adverse events. D3: Physical activity, depression scale, blood sugar level	R

(continued)

Table 1. Continued

Primary author, year	Country	Intervention	Patient group	Study design	Domains included and primary outcomes	Protocol (P) or reporting of results (R)
Vis, 2015	Denmark Germany Netherlands, Norway Scotland Italy Estonia Spain Greenland Turkey Wales	iCBT interventions in routine mental health-care practice	Adult patients from routine mental health-care practice	One group pretest-posttest design	D3: MANSA (Manchester Short Assessment of Quality of Life). D4: Acceptability, appropriateness of the treatment, satisfaction, CSQ-8 Client Satisfaction Questionnaire, System Usability Scale (SUS). D5: Costs of implementation and upscaling. D6: CSQ-3 Client Satisfaction Questionnaire	P

and re-tested until the prototype is ready for the final pilot test.[35] Often, testing in the real world presents new challenges not originally seen in a testing environment.[35,36] In Phase 3, the technology is tested in a real-life setting, for patients receiving clinical care. Successful examples of this process have been reported for telemedicine or telehealth strategies involving discharge planning and outpatient care of patients with chronic health conditions.[35,36]

The studies described show that PD is a suitable research design for the planning and implementation of telemedicine. Based on the studies of telemedicine we have learned that PD facilitates changes in the organisation and in its culture, and creates solutions and organisational changes required for implementation. The PD process relies on qualitative methods and is useful for engaging with stakeholders and encouraging ownership of the project.

Methods used in multidisciplinary assessment

Assessment of safety and clinical outcomes. In the current study we identified 16 journal articles and seven project reports that assessed the clinical effectiveness domain as part of the multidisciplinary assessment of telemedicine. Eleven journal articles reported the results of telemedicine interventions, and the remaining five articles were study protocols.

A number of outcome measures for studies of clinical effectiveness have been suggested in the MAST manual.[37] These include quality of life, health status, biometric measurement (e.g. HbA1c, weight, blood pressure), and health service utilisation (e.g. number of hospitalisations, number of clinic visits and number of emergency department presentations). The instruments and biometric measurements suggested in the MAST manual do not comprise an exhaustive list, and there exist many validated instruments and clinically relevant biometric measurements that could be used to assess clinical effectiveness of the telemedicine intervention. In the included articles these constructs have been measured using generic health-related quality of life instruments (e.g. SF-36,[38] Manchester short assessment of quality of life[39]) or disease-specific instruments (e.g. St George's respiratory questionnaire[40] or the Clinical COPD Questionnaire.[41]). The biometric measurements are typically those that would be used in clinical practice. Service utilisation is typically extracted from databases used in clinical practice.

Eleven of the included empirical studies used a RCT study design. One criticism of RCTs is that they measure the efficacy of a telemedicine intervention as opposed to the effectiveness. This is due to the controlled environment in which they sometimes operate, rather than the real world needed to measure effectiveness. Hence, clinical effectiveness may be better assessed using longer study periods, alternative study designs, for example prospective cohort study and performing the study only when the telemedicine intervention has normalised into everyday practice. On the other hand, the internal validity of these studies may be lower because of a higher risk of bias

that cannot always be controlled for. This does not preclude the need to perform RCTs to provide evidence supporting the normalisation of a telemedicine intervention.

There are a number of authors that support the ideals of multidisciplinary assessment such as MAST and suggest there is value in including complementary qualitative studies investigating perception and experience to any assessment of clinical effectiveness.[42,43] This can be achieved by bundling the MAST domains of clinical effectiveness, patient perspectives and organisational aspects. The patients and the staff's perception of a new telemedicine may have an effect on the clinical outcomes. Thus, in order to understand why an expected clinical outcome was achieved or not, findings in the patient and the organisational domain could be of high value. Thus, researchers should ensure complementary analysis of clinical, patient perspective, and organisational aspects to give a more comprehensive understanding of telemedicine interventions.

Assessment of patient perception. Thirteen studies include assessment of outcomes with the fourth domain of patient perception (Table 1). Most studies used general terms like user perception, user perspectives or patient experience when describing the outcome measures included. A number of studies (n=3) used validated questionnaires such as the Service User Technology Acceptability Questionnaire (SUTAQ)[10] and the System Usability Scale (SUS). SUTAQ includes 22 questions regarding patient acceptability of telemedicine, and based on the answers six acceptability scales can be estimated. The predictive validity of the instrument was recently confirmed.[44] SUS is a simple scale for usability test of IT systems including 10 questions with five response options.[45] It is technology independent and has been tested on technologies such as hardware, consumer software, websites, cellphones etc., and the validity has been demonstrated by comparison with more extensive usability scales.[46]

Both questionnaires and personal interviews have been used to assess patient perception. The advantage of interviews is the possibility of gaining a better understanding of the perception of the telemedicine service by the individual patient. On the other hand, questionnaires have the advantage of being able to collect information about the perception of a telemedicine service by a large number of patients. Further, questionnaires offer the possibility of combining the results in a simple, quantitative measure that can compare the patients' view of other telemedicine services. A further option is use both quantitative and qualitative methods (i.e. mixed methods) to gain a comprehensive understanding of a telemedicine intervention. Mixed-method techniques in telemedicine have been described elsewhere.[47]

Information about patients' perception and acceptability of telemedicine is still limited. This is a problem because even though patients are involved in the development of new technologies, for example by use of PD, patients' acceptance of telemedicine may vary – for example, 34% of the patients in the Italian part of the Review Health project declined to participate.[10] Hopefully it will be possible in the future to combine many studies of patients' perception of telemedicine and find an average level of acceptability with which new technologies can be compared. Similarly, there is a need for more research to identify patient groups with a lower than average degree of acceptability in order to be able to predict important factors (such as patient characteristics and resource requirements[10]) which may help improve the uptake of new telehealth services.

Assessment of economic aspects. Nine studies include a description of assessment of the economic aspects of telemedicine (Table 1). Of these, three are protocols and six report results from studies. Most studies claim to have done a cost-effectiveness analysis with estimation of the effect of telemedicine on the mean costs per patient from a healthcare or societal point of view, and one study calculates the business case for the hospital implementing the telemedicine service.[20]

MAST describes[2] that reporting of results should follow guidelines for reporting of health research and recommends a specific guideline for economic evaluation.[48] According to this detailed information about data collection, impact on quantities (e.g. number of contacts and admissions), prices, and statistical analysis should all be reported. Only one of the nine studies followed this guideline.[13] Most studies do not give detailed information about the economic analysis, but include information about the economic aspects as a section in the overall discussion of the results. This lack of quality in the reporting of economic evaluations of telemedicine is a general problem for studies of telemedicine, as described in a number of reviews.[49,50]

The studies that form the basis for the assessment of the economic aspects are generally based on RCTs. The main argument for RCTs is that this design has a high level of internal validity because it minimises the risk of systematic error (bias) by ensuring that the intervention and the control groups are similar in terms of both observed and unobserved characteristics. However, this may be at the expense of a low degree of transferability or external validity.[51] For example, if only highly motivated patients were included in a RCT in order to get a high level of compliance, the level of transferability of the results may be low. Similarly, if expensive IT solutions are used to improve engagement of patients and health professionals and thereby increase the success of the trial, it may end up making the home monitoring solution more costly than otherwise needed.

Therefore, economic evaluations of telemedicine can improve both by following guidelines for data collection and reporting of economic evaluations and by considering the economic consequence of selecting the specific research design. If the use of a randomised design in itself may increase the mean costs per patient, then alternative designs, such as observational studies or prospective cohort studies, need to be considered.

Assessment of organisational aspects. The implementation of telemedicine may introduce major organisational changes.[52] These changes include process change (e.g. workforce, staff training and resources, interaction, communication, task shifting), structural change (e.g. geographic spread), or cultural changes (e.g. culture, attitude, and management).[2] As a result, investigation of organisational aspects is included as a domain in the multidisciplinary MAST framework.

In the current study, we identified 10 peer-reviewed journal articles and one conference abstract that assessed the organisational aspects of a telemedicine intervention. Six journal articles published results from pragmatic analysis of actual telemedicine interventions, and the remaining five articles were protocol papers. Many of the published papers that conducted organisational analysis did so through the experience of the healthcare professional, or through the perception of the healthcare professional involved in the telemedicine intervention. A combination of healthcare professionals' experience and perception were used in a number of studies.[6,16,18] For example, Lamprinos et al.[18] explored healthcare professionals' experiences with workflow and efficiency consequences of managing patient using ICT-based interventions for diabetes self-management, and further explored the healthcare professionals' perceptions on the potential efficiency consequences in the mid-to-long term.

A group of constructs to investigate organisational aspects have been suggested in the MAST manual – for example, number of patients treated, referral times, changes in the number of staff resulting from the telemedicine intervention, changes in the number of face-to-face consultations, changes in the way members of the healthcare team communicate.[37] These constructs have been used with a high degree of fidelity in a number of included studies.[8,16,23] A number of studies introduce variations and new constructs – for example, job satisfaction,[16] facilitators and barriers of the telemedicine interventional,[24] and organisational restructuring.[21] Qualitative study design has been used to investigate organisational aspects in many of the included articles.[6,16,18,20,21,23,24] Typically, these studies collect data via qualitative interviews or focus groups with clinicians.

It would appear that rigorous qualitative methods have not been used in many of the evaluations in this domain. Notably, the small numbers of participants used in qualitative interview and focus groups are unlikely to have reached data saturation, analysis of data does not appear to use established methods (e.g. content analysis, thematic analysis), and reporting does not meet established guidelines (e.g. consolidated criteria for reporting qualitative research [COREQ][53]). Addressing these issues may improve the quality of the evaluation in this domain. However, it remains to be seen if improved reporting can be achieved given restrictive word counts in many journals.[47] As previously discussed a number of authors, for example Vis et al.,[27] have used validated survey instruments, for example SUS,[45] to assess healthcare professionals' perception and experience. However, other reports just describe that they have been using questionnaires 'based on MAST' without further information about content or validity of questionnaires.[8] Development of validated instruments for assessment of the perception of telemedicine would improve both the consistency and quality of research in the domain. A further limitation of the assessment of organisational aspects from the included studies is that generalisability of findings is difficult due to wide variation in services and contexts. To facilitate naturalistic generalisation which relies on a 'context dependant judgment of fit'[54] between services, inclusion of MAST's health problem and characteristics of the intervention should be included in studies that assess organisational aspects.

Limitations

The aim of this scoping review was not to evaluate the quality of the evidence, but rather to give an overview of the literature on MAST evaluations, and to identify potential research gaps. This review focuses on one specific assessment model, which does mean that other frameworks are excluded. We also acknowledge that MAST is relatively new, and therefore in time we expect to gain a clearer insight into its application and potential value in telehealth research.

Conclusion

This scoping review describes the uptake of MAST in the assessment of telemedicine applications, summarises the reported methods and research designs, and suggests areas for further research. The MAST multidisciplinary assessment offers the opportunity to assess a telemedicine application in seven domains; however, most of the included articles describe results within a single MAST domain. Researchers may focus on individual domains in articles depending on the research question and the word count limitations set by specific journals; however, it is recommended that, where possible, MAST is applied as a complete framework. Data collection in many of the included studies is often based on RCTs; in some cases this may be problematic because clinical, economic or organisational aspects are not fully included. Further, because of compliance issues with guidelines for reporting economic and organisational studies, generalisability is limited. This review paper highlights a need for more validated instruments for the evaluation of user experience and organisational effect; and more robust mixed methods to assess the MAST domains.

Declaration of Conflicting Interests

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References

1. Wade V, Gray L and Carati C. Theoretical frameworks in telemedicine research. *J Telemed Telecare* 2017; 23(1): 181–187.
2. Kidholm K, Ekeland AG, Jensen LK, et al. A model for assessment of telemedicine applications: MAST. *Int J Technol Assess Health Care* 2012; 28: 44–51.
3. Lampe K, Makela M, Garrido MV, et al. The HTA Core Model: A novel method for producing and reporting health technology assessments. *Int J Technol Assess Health Care* 2009; 25: 9–20.
4. Kidholm K, et al. Validity of the Model for Assessment of Telemedicine: A Delphi study. *J Telemed Telecare* 2016; 22: 1357633X16686553.
5. Arksey H and O'Malley L. Scoping studies: Towards a methodological framework. *Int J Soc Res Methodol* 2005; 8(1): 19–32.
6. Brandt CJ, Brandt V, Pedersen M, et al. Long-term effect of interactive online dietician weight loss advice in general practice (LIVA) protocol for a randomized controlled trial. *Int J Family Med* 2014; 2014: 245347.
7. Cano I, Alonso A, Hernandez C, et al. An adaptive case management system to support integrated care services: Lessons learned from the NEXES project. *J Biomed Inform* 2015; 55: 11–22.
8. Charrier N, Zarca K, Durand-Zaleski I, et al. Efficacy and cost effectiveness of telemedicine for improving access to care in the Paris region: Study protocols for eight trials. *BMC Health Serv Res* 2016; 16: 45.
9. Danbjørg, Dorthe Boe, Lis Wagner, et al. Designing, developing, and testing an app for parents being discharged early postnatally. *J Nurse Pract* 2014; 10: 794–802.
10. Dario C, Luisotto E, Dal Pozzo E, et al. Assessment of patients' perception of telemedicine services using the Service User Technology Acceptability Questionnaire. *Int J Integr Care* 2016; 16(2): 13.
11. Dario C, Delise P, Gubian L, et al. Large Controlled observational study on remote monitoring of pacemakers and implantable cardiac defibrillators: A clinical, economic, and organisational evaluation. *Interact J Med Res* 2016; 5(1): e4.
12. Dario C, Toffanin R, Calcaterra F, et al. Telemonitoring of type 2 diabetes mellitus in Italy. *Telemed e-Health* 2017; 23(2): 143–152.
13. Fasterholdt I, Gerstrøm M, Rasmussen BSB, et al. Cost-effectiveness of telemonitoring of diabetic foot ulcer patients. *Health Inform J* 2016; 22: 1460458216663026.
14. Garne K, Brødsgaard A, Zachariassen G, et al. Telemedicine in neonatal home care: Identifying parental needs through participatory design. *JMIR Res Protoc* 2016; 5(3): e100.
15. Hernández C, Alonso A, Garcia-Aymerich J, et al. Integrated care services: Lessons learned from the deployment of the NEXES project. *Int J Integr Care* 2015; 15: e006.
16. Iversen MM, Espehaug B, Hausken MF, et al. Telemedicine versus standard follow-up care for diabetes-related foot ulcers: Protocol for a cluster randomized controlled noninferiority trial (DiaFOTo). *JMIR Res Protoc* 2016; 5(3): e148.
17. Karhula T, Vuorinen AL, Rääpysjärvi K, et al. Telemonitoring and mobile phone-based health coaching among Finnish diabetic and heart disease patients: Randomized CONTROLLED TRIAL. *J Med Internet Res* 2015; 17(6): e153.
18. Lamprinos I, et al. Modular ICT-based patient empowerment framework for self-management of diabetes: Design perspectives and validation results. *Int J Med Inform* 2016; 91: 31–43.
19. Lewis KE, Gallefos F, Brown H, et al. Applying telemonitoring (TMon) post-admission for COPD, at scale: Preliminary findings from a large European trial. *Eur Resp J* 2016; 48: OA3521.
20. Minet LR, Hansen LW, Pedersen CD, et al. Early telemedicine training and counselling after hospitalization in patients with severe chronic obstructive pulmonary disease: A feasibility study. *BMC Med Inform Decis Mak* 2015; 15: 3.
21. Petersen IM, et al. Development and testing of the intelligent bed for heart failure patients: A feasibility study. *Int J Integr Care* 2015; 15: 7.
22. Rasmussen BS, Froekjaer J, Bjerregaard MR, et al. A randomized controlled trial comparing telemedical and standard outpatient monitoring of diabetic foot ulcers. *Diabetes Care* 2015; 38(9): 1723–1729.
23. Rasmussen BS, Jensen LK, Froekjaer J, et al. A qualitative study of the key factors in implementing telemedical monitoring of diabetic foot ulcer patients. *Int J Med Inform* 2015; 84(10): 799–807.
24. Ribu L, Holmen H, Torbjørnsen A, et al. Low-intensity self-management intervention for persons with type 2 diabetes using a mobile phone-based diabetes diary, with and without health counseling and motivational interviewing: Protocol for a randomized controlled trial. *JMIR Res Protoc* 2013; 2(2): e34.
25. Sorknaes AD, Bech M, Madsen H, et al. The effect of real-time teleconsultations between hospital-based nurses and patients with severe COPD discharged after an exacerbation. *J Telemed Telecare* 2013; 19(8): 466–474.
26. Torbjørnsen A, Jenum AK, Småstuen MC, et al. A low-intensity mobile health intervention with and without health counseling for persons with type 2 diabetes, part 1: Baseline and short-term results from a randomized controlled trial in the Norwegian Part of RENEWING HEALTH. *JMIR Mhealth Uhealth* 2014; 2(4): e52.
27. Vis C, et al. Implementing and up-scaling evidence-based eMental health in Europe: The study protocol for the MasterMind project. *Internet Intervent* 2015; 2.4: 399–409.
28. Ammenwerth E and Rigby M. Evolving health IT systems evaluation: The convergence of health informatics and HTA. *Evidence-Based Health Informatics: Promoting Safety and Efficiency Through Scientific Methods and Ethical Policy* 2016; 222: 220.
29. Østensen E, Svagård I, Fossberg AB, et al. Evaluation of ambient assisted living interventions-which tool to choose? *Nursing Inform* 2014; 18: 160–166.
30. Angel D, et al. Chapter 3: The model for assessment of telemedicine (MAST)–evaluation of telemedical solutions. *J Wound Care* 2015; 24(Sup5): S10–S13.
31. Clemensen J, Rothmann MJ, Smith AC, et al. Participatory design methods in telemedicine research. *J Telemed Telecare* 2016; 22. DOI: https://doi.org/10.1177/1357633X16686747 [Epub ahead of print].
32. Grønbæk K, Kyng M and Mogensen P. Toward a cooperatiove experimental system development approach. In: Mathiassen L and Kyng M (eds) *Computers and design in context*. Cambridge, Massachusetts: MIT Press, 1997, pp.201–238.

33. Jensen CM, Smith AC, Overgaard S, et al. "If only had I known": A qualitative study investigating a fast track treatment of patients with a hip fracture in Denmark. *Int J Qual Stud Health Wellbeing* 2017; 12(1): 1307061.
34. Danbjørg DB, Wagner L and Clemensen J. Do families after early postnatal discharge need new ways to communicate with the hospital? A feasibility study. *J Midwifery* 2014; 30(6): 725–732.
35. Danbjørg DB, Wagner L, Kristensen BR, et al. Intervention among new parents followed up by an interview study exploring their experiences of telemedicine after early postnatal discharge. *Midwifery* 2015; 31(6): 574–581.
36. Clemensen J, Larsen SB and Ejskjær N. Telemedical treatment at home of diabetic foot ulcers. *J Telemed Telecare* 2005; 11(suppl 2): 14–16.
37. MedCom and Norwegian Centre for Integrated Care and Telemedicine in association with University of Stirling & Norwegian Knowledge Centre for the Health Services MethoTelemed: Final Study Report 2010. Available at: http://www.renewinghealth.eu/c/document_library/get_file?uuid=43e4f98b-8e99-47b4-b355-32a6381069ed&groupId=28946 (accessed May 2017).
38. Stewart AL and Ware JE. *Measuring Functioning and Well-Being: The Medical Outcomes Study Approach*. Durham: Duke University Press, 1992p.xxiii, 449 p.
39. Priebe S, Huxley P, Knight S, et al. Application and results of the Manchester Short Assessment of Quality of Life (MANSA). *Int J Soc Psychiatry* 1999; 45: 7–12.
40. Jones PW, Quirk FH, Baveystock CM, et al. A self-complete measure of health status for chronic airflow limitation. *The St. George's Respiratory Questionnaire*. Am Rev Respir Dis 1992; 145: 1321–1327.
41. van der Molen T, Willemse BW, Schokker S, et al. Development, validity and responsiveness of the Clinical COPD Questionnaire. *Health Qual Life Outcomes* 2003; 1: 13.
42. Brunton L, Bower P and Sanders C. The contradictions of telehealth user experience in chronic obstructive pulmonary disease (COPD): A qualitative meta-synthesis. *PLoS One* 2015; 10: e0139561.
43. Ekeland AG, Bowes A and Flottorp S. Effectiveness of telemedicine: A systematic review of reviews. *Int J Med Inform* 2010; 79: 736–771.
44. Hirani SP, Rixon L, Beynon M, et al. Quantifying beliefs regarding telehealth: Development of the Whole Systems Demonstrator Service User Technology Acceptability Questionnaire. *J Telemed Telecare* 2017; 23(4): 460–469.
45. Brooke J. SUS - A quick and dirty usability scale. *Usabil Eval Industry* 1996; 189.194: 4–7.
46. Brooke J. SUS: A retrospective. *J Usabil Stud* 2013; 8(2): 29–40.
47. Caffery LJ, Martin-Khan M and Wade V. Mixed methods for telehealth research. *J Telemed Telecare* 2016; 22: 1357633X16665684.
48. Drummond M, Manca A and Sculpher M. Increasing the generalizability of economic evaluations: Recommendations for the design, analysis, and reporting of studies. *Int J Technol Assess Health Care* 2005; 21: 165–171.
49. Mistry H. Systematic review of studies of the cost-effectiveness of telemedicine and telecare. Changes in the economic evidence over twenty years. *J Telemed Telecare* 2012; 218.1: 1–6.
50. Mistry H, Hyeladzira G and Oppong R. Critical appraisal of published systematic reviews assessing the cost-effectiveness of telemedicine studies. *Telemed eHealth* 2014; 20(7): 609–618.
51. Murray E, Hekler EB, Andersson G, et al. Evaluating digital health interventions: Key questions and approaches. *Am J Prev Med* 2016; 51(5): 843–851.
52. Attkisson CC and Greenfield TK. The UCSF Client Satisfaction Scales: I. The Client Satisfaction Questionnaire-8. *The Use of Psychological Testing for Treatment Planning and Outcomes Assessment, 2nd ed.* Mahwah, NJ, US: Lawrence Erlbaum Associates Publishers, 1999, pp.1333–1346.
53. Tong A, Sainsbury P and Craig J. Consolidated criteria for reporting qualitative research (COREQ): A 32-item checklist for interviews and focus groups. *Int J Qual Health C* 2007; 19: 349–357.
54. Hellstrom T. Transferability and naturalistic generalization: New generalizability concepts for social science or old wine in new bottles? *Qual Quant* 2008; 42: 321–337.