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On the Road to Telemedicine Maturity: A Systematic Review and Classification of Telemedicine Maturity Models

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Abstract Telemedicine, seen as a solution for growing healthcare problems, is still not reaching its full potential. Telemedicine pilots can result in high costs, without successfully increasing patients' wellbeing as intended. Appropriate tools for scaling up telemedicine, like prescriptive maturity models, are needed. They can help people to assess the status quo and make progress with the scaling up process by presenting them with pre-defined improvement measures. Prior research has already led to the development of such tools, but an overview is still lacking as to which models fit which purpose and whether the measures presented are helpful and, if so, in what way. The aim of this research is to provide an overview and classification of existing prescriptive maturity models for telemedicine. A systematic literature review has been conducted and a classification scheme derived to assess the identified models. The resulting overview outlines a starting point for on-going research and presents a scheme for assessing existing models with regard to how fit they are for usage.

Keywords: • Models • Overview • Readiness • Telemedicine • Maturity •

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1 Introduction

Telemedicine, as part of eHealth, is seen as the solution to a number of problems in many healthcare systems. It promises to increase patients' access to care while decreasing costs (Hjelm, 2005). Even though first attempts at introducing telemedicine were already made in the 1960s (Thrall & Boland, 1998), the diffusion of this innovation is still hampered and telemedicine initiatives seldom reach regular care (Boonstra & van Offenbeek, 2010; van Dyk, 2014). This phenomenon is linked with the term "scaling up" that describes the process of bringing pilot projects to an increasing number of people who can benefit from them (Simmons, Fajans, & Ghiron, 2007). Without successfully scaled up telemedicine initiatives, high costs result from the development of telemedicine pilots without increasing the empowerment and wellbeing of patients, as intended. The need for scaling up has also been recognised by the European Commission (EC) and the World Health Organization (WHO), which have enlarged this expansion process, e.g. to new applications, organisations or territories (EC, 2015; Uvin, 1995) in their policy and research agendas (EC, 2015; WHO, 2009).

Maturity models are one tool that can successfully support scaling up (van Dyk & Schutte, 2012) by defining the status quo and guiding the following improvement process (Becker et al., 2010; De Bruin et al., 2005). Prior research has already reviewed existing telemedicine maturity models or tools and evaluated them from various foci (Mauco, Scott, & Mars, 2018; Yusif, Hafeez-Baig, & Soar, 2017). However, the studies do not help in identifying models which aim to proactively support the user and give substantial guidance for the improvement of the status quo. This paper, however, provides an overview of the current state-of-the-art of maturity models for telemedicine through the means of a systematic review. This should help researchers to address existing deficits in models and aspects for future research (Rowe, 2014). Furthermore, it should help practitioners to assess existing tools regarding their usage in ascertaining the readiness of a site or organisation to undertake a telemedicine initiative.

The remainder of this paper is structured as follows. In the next section, the concepts of telemedicine and maturity are introduced before the research method for identifying existing models is explained in section 3. Afterwards, the classification scheme to compare the identified models is developed (section 4)

and applied (section 5). The results from the previous sections are then discussed (section 6), before conclusions – accompanied by an outlook for future work – are put forward (section 7).

2 Telemedicine and Maturity

Telemedicine, as part of eHealth, describes the location- and time-independent delivery of healthcare services and/or medical education by professionals through the use of information and communication technology (ICT) (Sood et al., 2007). Healthcare disparities, especially in rural or underserved areas, can be overcome by the use of telemedicine since it connects electronically patients and professionals who are geographically distributed (Zapka et al., 2013).
Telemedicine initiatives are highly complex, and are influenced not only by their users, their behavioural and ethical concepts, but also by surrounding factors like legal, organisational or financial conditions (Broens et al., 2007; Ly et al., 2017). To successfully scale up telemedicine initiatives, this complexity needs consideration. Addressing telemedicine initiatives' complexity is mostly done prior to implementation by referring to "telemedicine readiness". Readiness describes the "degree to which users, healthcare organisations, and the health system itself, are prepared to participate and succeed" (The Alliance for Building Capacity, 2002, p. 2) with telemedicine implementation. Supporting tools for telemedicine scaling up should include the provision of improvement measures, by helping users understand which steps could be taken in what context and by guiding them during the implementation process. As one such support tool, a maturity model describes a path to reach an advanced stage of maturity, including the definition of the current status quo, an overview of next steps, and the provision of a common understanding for different stakeholders to work on (Katuu, 2016; Klimko & Remenyi, 2001). Being mature is hereby defined as "having reached the most advanced stage in a process" (Oxford Dictionaries, n.d.). The entity under consideration can be people, processes or objects (Klimko & Remenyi, 2001).

Maturity models typically consist of dimensions – that are described and that reflect the domain to which the model refers – and levels, including a descriptor (e.g. initial, defined, optimising) and characteristics for each level (Fraser, Moultrie, & Gregory, 2002). Depending on the model's design, three types of models have been differentiated: Capability Maturity Model (CMM)-like models,

Likert-like questionnaires, and maturity grids. CMM-like models are based on a formal design: a specific number of levels are described, with no further details for each activity per level. Likert-like questionnaires are seen as simple maturity models where each question displays a good practice and needs to be ranked by the respondent with a score, mostly from 1 to n. No additional information for each score is provided. Maturity grids describe each level of each dimension in a textual manner and further guide the assessment process (idem).

Independent from the type of maturity model used, each model can be descriptive, prescriptive or comparative in nature. Descriptive maturity models describe the as-is situation, while prescriptive models further add the provision of steps for improvement from that point on. Comparative maturity models permit comparison between different industries or regions but require that a wide range of adequate data is collected. This requires the development of a descriptive model first, before understanding and addressing the need for improvement in a prescriptive model (De Bruin et al., 2005).

3 Method

A systematic literature review was conducted to identify relevant maturity models. To avoid bias by exclusively searching articles in leading journals, we searched in various databases (Webster & Watson, 2002). PubMed/Medline, AISeL, Academic Search Complete (via Ebsco Host), ScienceDirect and Web of Science were considered to be relevant databases.
Some discretion had to be used with regard to the terms chosen. The search string was widened at an early stage of the research. The term "telemedicine" is not used consistently in the literature (Bashshur, Shannon, & Sapci, 2005), which led to the inclusion of related terms (Meskó et al., 2017; Otto et al., 2018) to lower the bias involved in having different understandings of terms: a number of synonyms were tested or added to the search string. The same was done for "maturity" (examples included "readiness", "scaling up", "preparedness" and "assessment") and for "model" (additional kinds of instruments were included in the search).

The following search string was applied to title, abstract and keywords because some variety of these terms should appear in these three fields if the topic is indeed a major one in the paper investigated:

- "((telemedicine OR telehealth OR ehealth OR "e-health" OR "digital health") AND
- (maturity OR readiness OR "scaling up") AND
- (model OR framework OR tool OR level))".

The literature search led initially to 291 results which were screened step by step (see Figure 1 for the PRISMA flow chart (Moher et al., 2009)). Articles were included if they focussed on an instrument to assess the maturity of a telemedicine initiative (or related technologies) as a whole. To clarify, such an instrument implies that the measurement of the status quo can be achieved through the application of a model which distinguishes different levels of maturity. Articles that solely collected factors without measuring the status quo or that explored exclusively a specific form of readiness (e.g. organisational readiness, instead of a wider focus) were excluded. Two authors read and assessed titles, abstracts and full texts independently. Inconsistencies in decisions were resolved through discussion and consensus, leading to the inclusion of seven articles.

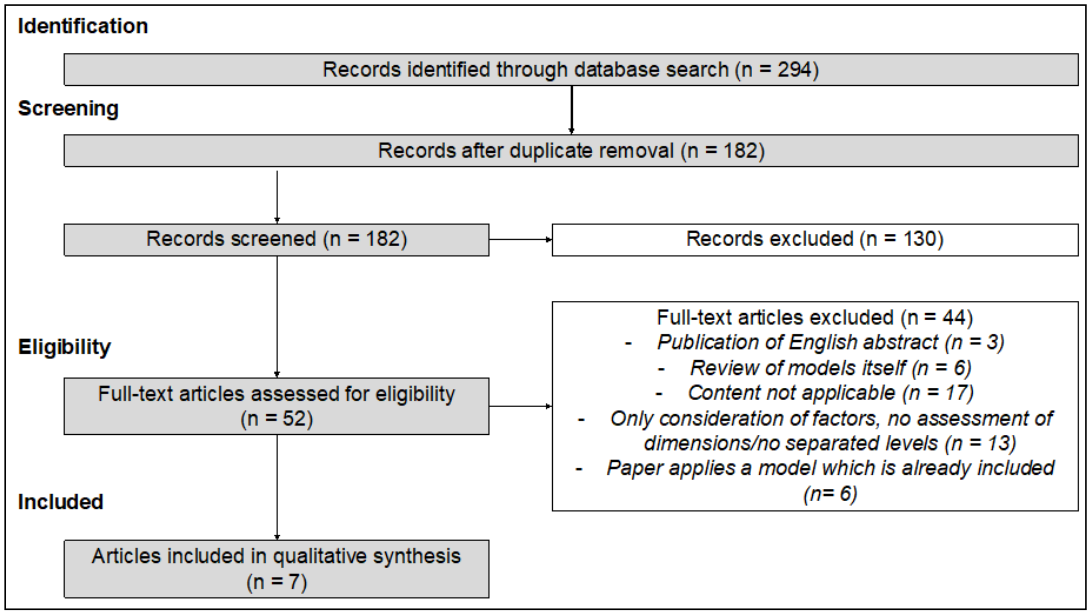

Figure 1: PRISMA flow chart

Due to the fast-moving pace in the telemedicine field and the relevance of maturity models beyond solely research, a grey literature search (Tillett & Newbold, 2006) was additionally conducted, to identify maturity models that have not yet been published in the academic literature. The search for alternative sources via the World Wide Web yielded three additional results on which all authors agreed. In the end, ten models were considered.

To assess and compare existing maturity models, classification characteristics were defined. The classification scheme for maturity models of Mettler et al. (2010) was taken as a basis as its focus is on characteristics that describe maturity models in general. Further attributes were added to the scheme, in order to obtain a more detailed impression of each model. These include, e.g., characteristics of maturity models and of telemedicine initiatives (which help selecting an appropriate tool in the complex field of telemedicine with its different stakeholders, applications and technologies).

4 Technology in Sheltered Accommodation

The proposed classification scheme was subject to a four-part examination: Research information, general model attributes, maturity model design, and maturity model use. Each **category** (displayed in bold in Table 1) consists of related *attributes* (in italics) with alternative characteristics (displayed in grey) that are described in detail below.

Table 1: Classification scheme (attributes from Mettler et al. (2010) are underlined)

Research information	**General model attributes**	**Maturity model design**	**Maturity model use**
1.1 Author *1.2 Year* *1.3 Title of publication* *1.4 Identified via review or grey literature search*	*2.1 Name of the model* *2.2 Acronym* *2.3 Addressed topic* *2.4 Origin* (academia | practice | government | combination) *2.5 Purpose* (descriptive | prescriptive | comparative) *2.6 Respondents* *2.7 Technology* (telemedicine | telehealth | eHealth | digital health) *2.8 Perspectives considered* *2.9 Country* *2.10 Disease* *2.11 Availability* (free of charge | not free of charge)	*3.1 Concept of maturity* (maturity of: processes | objects | people | combination) *3.2 Design strategy* (development of a new model | adaptation/combination of existing models) *3.3 Development method* *3.4 Composition of the model* (Capability Maturity Model-like model | Likert-like questionnaire | maturity grid) *3.5 Dimensions* *3.6 Levels* *3.7 Reliability* *3.8 Mutability* (form | function | form and function)	*4.1 Method of application* (self-assessment | third-party assisted assessment | certified professionals) *4.2 Support of application* (documentation | textual description | handbook | supporting tool) *4.3 Practicality of evidence* (general recommendations | specific improvement activities) *4.4 Further usage of the model*

Identifying attributes like *author(s), year, title of publication* and whether the text had been identified via the *review or grey literature search* belong to the category **research information.**

Furthermore, ***general model attributes*** (Mettler et al., 2010) like *name* and *acronym* of the model and the *addressed topic* (idem) were collected to obtain a first impression of the models. Other attributes include the *origin* (De Bruin et al., 2005; Mettler et al., 2010) and *purpose* of the model (De Bruin et al., 2005; Poeppelbuss et al., 2011) as well as *respondents* (De Bruin et al., 2005), i.e. who is intended to apply the model, the *technology* covered and the *perspectives considered*, i.e. factors of/around a telemedicine initiative (e.g. patients or legal aspects). Additionally, *country* or *disease* specificity and the *availability* of the model were collected (Mettler, 2011; Mettler et al., 2010).

Attributes describing the **maturity model design** (Mettler et al., 2010) concentrate on the core characteristics of each model. Firstly, the *concept of maturity* (Mettler, 2011; Mettler et al., 2010), was collected as well as *design strategy* (Leyh et al., 2017), and *development method*, e.g. process description for developing maturity models (design science or procedure models (e.g. Poeppelbuss & Roeglinger, 2011)) or other methodological approaches, like focus groups or interviews. Secondly, the model itself is represented by the attributes *composition of the model* (Mettler et al., 2010), the *dimensions* and *levels* (De Bruin et al., 2005; Lasrado, Vatrapu, & Andersen, 2015). Thirdly, *reliability* and *mutability* (regarding form, e.g. the scheme or question items included, and/or function, e.g. the assessment of maturity itself) of each model were identified (Mettler et al., 2010).

Also, the **maturity model** use is an element on which to focus. The *method of application* describes who assesses the maturity, while *support of application* examines what supporting material is provided. Furthermore, this attribute may or may not indicate how far existing material/software tools are supported or contact persons are named. The third attribute in this category is *practicality of evidence* (Mettler et al., 2010). The classification scheme of Mettler et al. (2010) focusses strongly on the retrievability and reusability of existing models, leaving aside their "real use", i.e. their application by others. However, maturity models are developed for their application in a natural setting, which is why the attribute of *further usage of the model* was added to the scheme. This attribute examines the

application and further development of and whether a potential (stakeholder) community had been built around any given model.

5 Maturity Models for Telemedicine

Analysing the classification of all the identified models was done in two steps. Firstly, due to the high variety in the models' focus and structure, each model was described individually. Secondly, general statements were defined about all models. Corresponding attribute numbers are displayed in italics referring to Table 1. After the analysis, indications were identified how far each model supports its users proactively in scaling up telemedicine initiatives.

5.1 Individual Statements

Individual statements can be drawn for each model according to author and year of publication (*1.1 and 1.2*), name and acronym of the model (*2.1 and 2.2*), topic addressed (*2.3*) and country developed in (*2.9*). While some models are restricted in their use to the country they were developed in, others are more general. Detailed information can be found in Table 2.

Table 2: Individual information for each model (sorted by date of publication)

Author (Year)	Name of the model (Acronym)	Topic addressed	Country (use restricted/not)
Campbell et al. (2001)	Framework for assessing provider's readiness to adopt telemedicine	Readiness for telemedicine of health providers	Developed in Missouri, United States (no restriction reported)
Jennett et al. (2003)	Framework for rural and remote readiness in telehealth	Readiness for telehealth of different stakeholders within a community	Developed in Canada (no restriction reported)
Broens et al. (2007)	Layered implementation model	General determinants for successful telemedicine services	Western societies (restricted use)
Khoja et al. (2007)	E-Health Readiness Assessment Tools for Healthcare Institutions in Developing Countries	e-Health readiness of managers and healthcare providers in healthcare institutions	Pakistan/developing countries (restricted use)
Van Dyk and Schutte (2012)	Telemedicine Maturity Model (TMMM)	Maturity of telemedicine services and their related factors and processes	Developed in South Africa (no restriction reported)
Abera et al. (2014)	Strategy, Technology, Organization, People and Environment (STOPE) model	e-Health readiness in healthcare institutions (in Ethiopia)	Ethiopia/ Sub-Saharan Africa (restricted use)
Jensen et al. (2015)	MOMENTUM-TREAT toolkit	Readiness of telemedicine services for large-scale deployment	Developed in Europe (no restriction reported)
Sokolovich and Fera (2015)	UPMC Telehealth Adoption Model	Maturity of telemedicine services and their readiness to expand	Developed in the United States (no restriction reported)
Gholamhosseini and Ayatollahi (2016)	E-Health readiness assessment tool	e-Health readiness in healthcare institutions	Iran (restricted use)
iCOPS (2017)	Commissioning Technology Enabled Care Services	Readiness of TECS before adopting or expanding	Developed in the United Kingdom (no restriction reported)

The composition of the model with its dimensions, levels (*3.4 - 3.6*) and intended respondents (*2.6*) needs to be analysed individually. Also, reliability (*3.7*) and further usage (*4.4*), identified via forward search, are considered.

The oldest identified model was developed by Campbell et al. (2001). The six dimensions of turf, efficacy, practice context, apprehension, time to learn and ownership are crossed with the three levels of fertile soil, somewhat fertile soil and barren soil. The model is similar to a maturity grid and its focus on telemedicine providers leads to the inclusion of physicians, nurses and administrative staff as target groups of the model. Reliability tests are not reported and further development or usage of the model could not be identified.

Two years later, Jennett et al. (2003) published their model as a kind of maturity grid. The four identified stakeholder groups, patient, practitioner, public and organisation, serve as dimensions, crossed with four types of readiness: core, engagement, structural and non-readiness. Each type of readiness contains six different themes arising for all stakeholders at all times (core readiness, structural readiness, projection of benefits, assessment of risk, awareness and education, and intra-group and inter-group dynamics). Nevertheless, this initial model cannot be considered as an actual maturity model since the readiness themes do not necessarily have a relationship with each other or describe an evolutionary path (The Alliance for Building Capacity, 2002), i.e. levels are missing. The initial model was not tested by the authors, but has been further developed. In 2004, three 5-point, Likert-like questionnaires were designed for organisations, patient/public and practitioners (NSW Agency for Clinical Innovation, 2015). Each questionnaire results in one of three readiness levels (being in a good position for implementation; some items may hinder a successful implementation; and remaining barriers needing to be addressed). This survey has further been translated into and validated in various languages (Légaré et al., 2010) and applied in other countries (Muigg et al., 2018; Schwarz, Ward, & Willcock, 2014).

Broens et al. (2007) ordered their five identified determinants of technology, acceptance, financing, organisation, as well as policy and legislation, in a layered implementation model (which can be classified as a CMM-like model). Each determinant builds on the previous one, indicating that the levels increase from determinant to determinant. The authors identify different telemedicine stakeholders, but the target audience of the model is not stated explicitly. The model remains untested, and is not easily benchmarked (van Dyk and Schutte, 2012).

Khoja et al. (2007) focus on healthcare institutions in developing countries. Two 5-point, Likert-like questionnaires were provided, one for managers and another for healthcare providers. Both questionnaires included the three dimensions of core-readiness, societal readiness, and policy readiness. For managers, the dimension "technological readiness" was added; healthcare providers additionally assess the dimension "learning readiness". The authors conducted validity and reliability testing and showed good content and face validity and high reliability for both questionnaires. The tool has been applied in different settings (e.g. Chipps & Mars, 2012) and was taken up again partly in the development of the Khoja-Durrani-Scott framework (Khoja et al., 2013). Unfortunately, the surveys for the framework (referenced by Khoja et al. (2013)) are not available online anymore.

Five years later, van Dyk and Schutte (2012) presented a maturity grid in the form of a three-dimensional cube, based on existing models (e.g. by Broens et al. (2007), Jennett et al. (2003) and Khoja et al. (2007)). The cube consists of five dimensions (technology, users, finances, procedures and policy) which are crossed with the steps of the underlying telemedicine process. Each box in this matrix is then rated at one of five levels (initial; managed; defined; measured process; optimising). A target audience is not clearly stated. Nevertheless, the authors applied and validated their model with the help of workshops and focus groups, involving healthcare professionals (doctors and nurses) as well as technical staff members responsible for information technology from different regions. Later usage of the model has only been found in the further development by the same authors (van Dyk & Schutte, 2013). However, this further developed model is even more complex than the original, and contradicts the expectation that a maturity model should be easy to understand and use (Klimko & Remenyi, 2001).

Abera et al. (2014) present two 5-point, Likert-like questionnaires where the dimensions of the STOPE model (Strategy, Technology, Organisation, People and Environment) are ranked and related to a colour code from the McConnell International tool, thereby implying that the site/location has a certain level of readiness. Opinions about the three dimensions, strategy, organisation and environment, were collected from managers and administrative staff by using a single questionnaire. Another questionnaire was administered to healthcare professionals and information technology staff and included the dimensions of

technology, people and environment. Validity and reliability tests were undertaken. However, the model seems not to have been used further.

Jensen et al. (2015) combined the MOMENTUM blueprint with the Telemedicine Readiness Self-Assessment Tool (TREAT) and got the MOMENTUM-TREAT toolkit. This toolkit is a 5-point, Likert-like questionnaire, assessing various indicators from 18 critical success factors which are categorised into the four areas of context, people, plan and run. The toolkit can be adapted to different settings by its users, which are described as "telemedicine doers and decision-makers" (Jensen et al., 2015, p. 32). All indicators were validated and tested and the toolkit has been applied in different settings, e.g. by Walters et al. (2016).

In the same year, Sokolovich and Fera (2015) presented the UPMC (University of Pittsburgh Medical Center) model as a conference presentation in which the development process and structure of the model were introduced. Therefore, little information is available regarding the model. A clear statement on the respondents of the model is missing, but it can be determined that the tool was based on a practitioner survey in different health facilities. The model is a CMM-like model with eight levels (from 0 to 7: governance, providers, patients, simple, complex, complete, expanded, integrated). Further statements on application or testing of the model cannot be made with the limited information publicly available.

Another 5-point, Likert-like questionnaire was published by Gholamhosseini and Ayatollahi (2016). It consists of five dimensions (e-health readiness, ICT functions, environmental readiness, human resources readiness, ICT readiness), including different indices. Each index is assessed on the Likert scale and multiplied with an additional weight for each dimension, resulting in a score between 0 and 1. A literature search for other tools on which the questionnaire can be built, e.g. Khoja et al. (2007), has been undertaken, but it is not explicit which parts of which models were considered. A clear statement about who the intended respondents are is also missing. The authors applied their model with the help of hospital employees, including managers, health professionals and technical staff. Validation was conducted during the development phase of the model. Further usage of it could not be found.

Most recently developed was the maturity grid by iCOPS (2017). It is presented as an online tool, incorporating standards from a code of practice developed by Donelly (2017). The tool contains 16 dimensions (e.g. involvement of stakeholders, users and carers; investment and funding; implementation), which can be rated using four levels (inadequate; requires improvement; good; or outstanding). Different descriptions for each dimension and level are provided. The tool can be used by "all staff responsible for planning, commissioning, procuring, project and contract managing" (iCOPS, 2017) in technology enabled care services, but it is not available free-of-charge. Information on testing or application of the model is not publicly available.

5.2 General Statements

A number of general statements can be made for each of the four categories.

Research Information

While author and year of each publication (*1.1 and 1.2*) are shown in Table 2, each publication title (*1.3*) can be found in the reference list. Publication dates for the model range from 2001 to 2017 (see Figure 2). In fact, the topic of telemedicine maturity is not a new one, but interest in it has increased over the last five years (*attribute 1.2*).

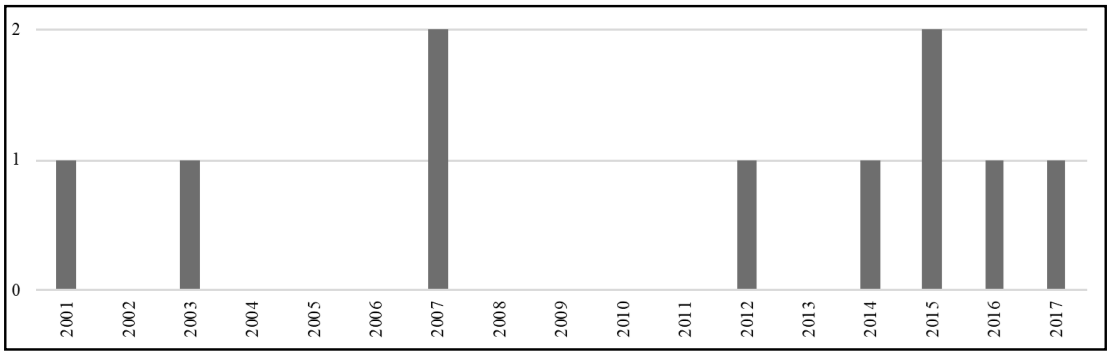

Figure 2: Number of models per year

Seven of the ten models were identified via the literature review; three, which are among the latest four to be made available, by the grey literature search *(1.4)*.

General Model Attributes

The name, acronym, topic and country developed in *(2.1 - 2.3 and 2.9)* of each model can be found in Table 2. The seven models identified via the literature review all originate from academia. From the three models identified through grey literature search, two were created by practitioners (iCOPS, 2017; Sokolovich & Fera, 2015) and one from a combination of academic, practitioner and governmental stakeholders (Jensen et al., 2015) *(2.4)*.

Regarding purpose *(2.5),* nine out of the ten models outlining the status quo are descriptive models that make no recommendations. Only one model addresses the improvement of the status quo, i.e. is a prescriptive model (Campbell et al., 2001). Intended respondents for each model *(2.6)* were analysed individually in section 5.1.

Four models are classified as being applicable to telemedicine (Broens et al., 2007; Campbell et al., 2001; Jensen et al., 2015; van Dyk & Schutte, 2012), one to telehealth (Jennett et al., 2003), and two to eHealth (Gholamhosseini & Ayatollahi, 2016; Khoja et al., 2007). Two others are applicable to telemedicine and telehealth (iCOPS, 2017; Sokolovich & Fera, 2015), and a further one to telemedicine and eHealth (Abera et al., 2014) *(2.7)*.

Each model covers various perspectives of telemedicine initiatives *(2.8)*, as displayed in Table 3. The perspectives, i.e. core readiness through to legal readiness, were derived by the authors of this article by examining the items mentioned in all ten models.

Table 3: Perspectives on telemedicine initiatives covered in each model – "x": perspective is directly included, "(x)": perspective is indirectly included in the model

	core readiness	provider readiness	patient readiness	public/ community readiness	health sector readiness	strategic readiness	technological readiness	organisational readiness	financial readiness	legal readiness
Campbell et al. (2001)	(x)	x								
Jennett et al. (2003)	x	x	x	x	x	x	x	x	x	x
Broens et al. (2007)		x	x		x	x	x	x	x	x
Khoja et al. (2007)	(x)	x	x		x	x	x	x	x	x
Van Dyk and Schutte (2012)		x				x	x	x	x	x
Abera et al. (2014)	(x)	x	x		x	x	x	x	x	x
Jensen et al. (2015)		x	x	x	x	x	x	x	x	x
Sokolovich and Fera (2015)		x			x		x	x		
Gholamhosseini and Ayatollahi (2016)	(x)	x				x	x			(x)
iCops (2017)		x	x		x	x	x	x	x	x

No clear trend can be seen in the various types of readiness having been added over time. Rather, the authors of the ten models combined different types of readiness for their own purposes, without necessarily claiming to be holistic in their approach.

None of the models are disease-specific *(2.10)*.

Eight of the models are available free-of-charge *(2.11)*, but not two of the models developed by practitioners, which limits the usability of both models (iCOPS, 2017; Sokolovich & Fera, 2015). For the iCOPS (2017) tool, users can undertake a one-month free trial to test the tool.

Maturity Model Design

In general, seven out of the ten models combine process-, object- or people-focussed elements *(3.1)*. Only three focus specifically on the maturity of people (Campbell et al., 2001; Jennett et al., 2003; Khoja et al., 2007).

Most identified models were designed as new models (6/10) or combined/extended for the first time (4/10) (see Figure 3 for *3.2 and 3.3*). However, for none of the models was a theory (e.g. regarding adoption or diffusion) incorporated to strengthen its theoretical basis.

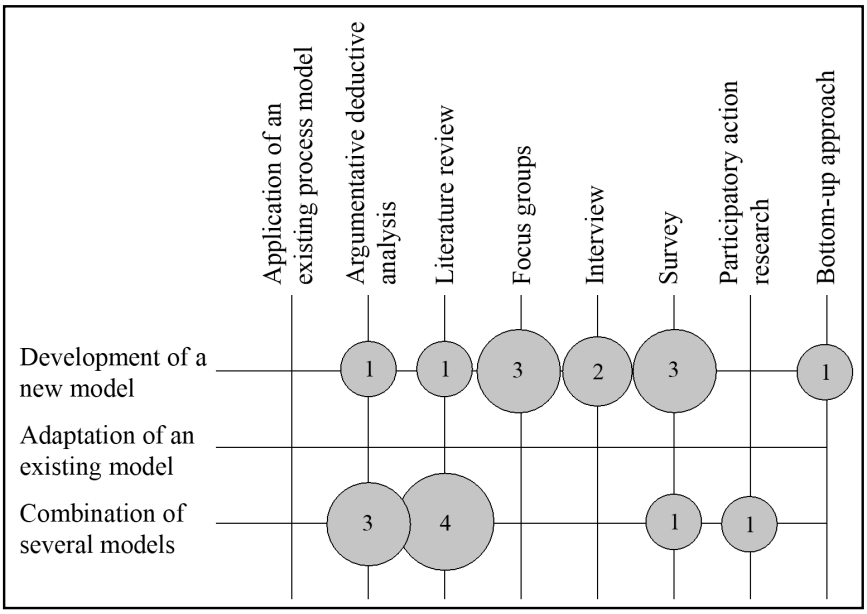

Figure 1: combination of design strategy and development method (size of and number within each bubble represent the number of times each combination was identified)

Information about model composition, dimensions, levels and reliability *(3.4-3.7)* were also discussed in section 5.1. The mutability of models *(3.8)* is not addressed in seven of the models. Jensen et al. (2015) and Khoja et al. (2007) directly report a possible mutability regarding the form of the model; Van Dyk and Schutte (2012) name a form and function mutability.

Maturity Model Use

All the models can be used as self-assessment tools *(4.1)*. Nevertheless, support/guidance for the application *(4.2)* is not given in eight out of the ten models. Even though each of the models is described in the individual publications, largely no form of additional support is provided to guide later users in the models' application. This observation also applies to the work of Abera et al. (2014), Gholamhosseini and Ayatollahi (2016) and Van Dyk and Schutte (2012), who all applied their models directly to the assessment of specific institutions/processes. These later authors only described the content of the models, and failed to offer detailed descriptions that would be helpful for reuse. Support for the application of the models is only given in two of the models. These are Jensen et al. (2015), with a step-by-step procedure to applying the model and the naming of an email address for further support, and iCOPS

(2017), where a software assessment tool is provided and an email address for further questions.

Regarding practicality of evidence *(4.3),* it can be said that only one model offers general recommendations (Campbell et al., 2001), specific improvement activities are not given in any of the models. Generally, in all of the models the description of the more mature stages of telemedicine could also offer guidelines on improvement measures (since they would explain the circumstances of higher maturity), but they do not give direct guidance. Each model was further used differently *(4.4)* as described in section 5.1.

6 Discussion

Existing models have been developed to assess a site's or an organisation's readiness for beginning a telemedicine initiative rather than to measure the maturity of telemedicine initiatives. Focussing on readiness is a necessary preliminary step in order to reach successful change and adoption (The Alliance for Building Capacity, 2002). This aligns with the focus on maturity models in this paper, where a maturity model is seen as a supporting tool that has dimensions and levels which can also incorporate the maturity of readiness. Even though some of the models focus on eHealth or telehealth instead of telemedicine, the perspectives covered in each model are similar.

While the maturity models analysed have different characteristics and foci that are identified in this paper, two main challenges remain from the analysis which will require on-going research to enhance future application of the models.

Firstly, almost all the models are descriptive: they do not provide support for applying possible improvement steps. Although higher levels of maturity can imply improvement measures by describing the circumstances of higher maturity, clear guidance is missing. Three models, i.e. Campbell et al. (2001), iCOPS (2017) and Jensen et al. (2015) provide high-level guidance or supply approaches to guide users in helping themselves (by providing measures or steps to define an improvement process), but they do not include actual assistance or specific improvement steps. A clear need can therefore be identified to explicitly address users of the models with guidance not only in how to assess the status quo but

also to improve the status quo in the future through the application of specific, detailed measures.

Secondly, in eight out of the ten models (i.e. all the models except the ones by Jennett et al. (2003) and Jensen et al. (2015)), insufficient consideration has been paid to patients, as care recipients, and/or the community/public surrounding them, although they are essential partners to telemedicine adoption (Yusif et al., 2017). Therefore, incorporating adoption (e.g. Venkatesh, Thong, & Xu, 2012) and community readiness theories (Edwards et al., 2000) should be discussed in a stronger way, in order to close this identified gap. Addressing both challenges (adoption and community readiness) would help in proactively supporting telemedicine scaling up. In their current form, none of the models analysed serves the purpose of proactively supporting its users by giving substantial guidance for further improvement of the status quo.

Turning to potential study weaknesses: this review could be considered to have a number of limitations – by the search string applied, the databases selected, and by the fact that the inclusion and exclusion of literature is a highly subjective procedure. Nevertheless, to counterbalance these potential weaknesses, relevant synonyms for all terms were tested for results and a representative set of databases was chosen. Furthermore, two researchers independently assessed the inclusion and exclusion of articles, and the categorisation of identified models. Last but not least, the classification scheme developed also limited the scope of the work, since it described only a selected number of characteristics while attempting to illustrate the diversity of the topic – a difficulty also uncovered by Mettler et al (2010).

7 Conclusion

Identifying existing maturity models for telemedicine and assessing them in a structured classification scheme (which can be re-used for classifying additional or newer maturity models) led to an overview of the state-of-the-art. We pointed out the various facets and limitations of each model and the specific setting for which the models have been developed. Most of the models considered are missing important perspectives on telemedicine initiatives or ignore the need for improvement processes to be introduced for their implementors to reach a higher level of maturity. By questioning the models' feasibility to assess

telemedicine initiatives proactively, our analysis shows that users are often left alone to apply any given model, since practical support for a model is seldom provided.

All in all, the need has been identified to make available a prescriptive maturity model, that proactively guides its users in assessing and improving the status quo. One aspect for future research may be the combination of existing models with adoption and community readiness theories, so as to cover all of the perspectives relevant to telemedicine in a holistic manner. In addition to the provision of e.g. a webtool, the usage of the model should be described in detail in any associated documentation. In terms of the design method, relevant stakeholders, e.g. patients and practitioners, should be included in the model's development to ensure their perspectives are represented.

With such a model and an accompanying online tool, the readiness of a site to implement a telemedicine initiative would be a goal that could be achieved in a faster way. Proactive guidance would be provided to the users on the road to telemedicine maturity, which in turn could support cost savings while increasing the wellbeing of patients through more successful telemedicine initiatives.

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