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RESEARCH PAPER

A Maturity Model for Assessing the Digitalization of Public Health Agencies

Development and Evaluation

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Abstract Requests for a coordinated response during the COVID-19 pandemic revealed the limitations of locally-operating public health agencies (PHAs) and have resulted in a growing interest in their digitalization. However, digitalizing PHAs – i.e., transforming them technically and organizationally – toward the needs of both employees and citizens is challenging, especially in federally-managed local government settings. This paper reports on a project that develops and evaluates a continuous (vs. a staged) maturity model, the PHAMM, for digitalizing PHAs as a cornerstone of a digitally resilient public health system in the future. The model supports a coordinated approach to formulating a vision and structuring the steps toward it, engaging employees along the transformation journey necessary for a federally-managed field. Further, it is now being used to allocate substantial national funds to foster digitalization. By developing the model in a coordinated approach and using it for distributing federal resources, this work expands the potential usage cases for maturity models. The authors conclude with lessons learned and discuss how the model can incentivize local digitalization in federal fields.

Keywords Digital maturity · Digitalization · Public health offices · Maturity models

1 Introduction

Locally-operating public health agencies (PHAs) were central to managing the COVID-19 pandemic and, in this way, providing crucial health services for all citizens. As for most countries, Germany's 375 PHAs had received relatively little public attention before the pandemic (Arnold and Teichert 2021). This changed, with reports about staff shortages and insufficient digital infrastructure during the pandemic's emergence, revealing the weaknesses of an underfunded federal health system (Behnke and Zimmermann 2020; Schreyögg 2020). In particular, contact tracing as a key part of limiting the outbreak of COVID-19 (RKI 2016, 2020) challenged PHAs' limited personnel and IT resources. To mitigate these challenges, many countries' governments provided financial resources for digitalizing their PHAs (Maani and Galea 2020; Sanfelici 2020). Thus, the crisis triggered innovation and modernization (Boin et al. 2020), helping PHAs to build digital capacities to manage this and potential future crises for more resilient service provision to citizens.

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However, digitalization in PHAs is impeded owing to the local autonomy of PHAs and decision-making strategies restrained by institutional contexts and government modes (Behnke and Zimmermann 2020; Gruhl 2020; Kuhlmann et al. 2021). Federally-managed countries such as Germany need to follow a consensus approach, which involves negotiation between central institutions and the 16 federal states (Rechel et al. 2018; Kuhlmann et al. 2021). In Germany's public health system, this federal organization has led to dissipated organizational structures with various technical facilities and regional laws, a lack of interoperability, and fragmented and sometimes rivaling strategies (Gruhl 2020), negatively impacting a PHA's efficiency and effectiveness and impairing seamless cooperation with its stakeholders. Thus, PHAs lack technical and organizational capacities for employees to put citizens at the center of their service offering. Implementing and harmonizing technical solutions across regionally-operating PHAs (e.g., by introducing national software solutions) is challenging owing to the required consensus among federal decision-makers. In line with this, the research has suggested that centralized IT would improve government performance (Denford et al. 2020), while consensus mechanisms among federal decision-makers can paralyze technological advances and can hinder digital resilience (Dunleavy et al. 2006). To digitalize federally-organized countries' PHAs, we ask:

How Can Federally-managed PHAs, Which Must also Operate in Crises, Mature Digitally?

We argue that guiding the digitalization of PHAs in a federally-managed field requires an approach that supports reaching a consensus on a jointly negotiated digitalization goal and transformation process. Once the federal states agree on both, their PHAs can act in de-centralized ways while still being embedded in a harmonized endeavor of nationwide technological digital transformation. Maturity models (MMs) are an established IS approach to help formulate a clear vision and differentiate steps toward it (Subba Rao et al. 2003; Mehta et al. 2007; Becker et al. 2009). Further, MMs can be developed in a coordinated approach that supports the negotiation-based path in a federally-managed field. The research has confirmed MMs' ability to improve organizations' capacity concerning the aspect(s) they are intended to support (e.g., project management, readiness for IT security). But, as yet, no existing MM reflects a shared vision of PHA digitalization, nor are there suitable MMs that take the required holistic view, i.e., one that considers standardization processes across the entire system landscape and providing a timeline for successfully managing the various steps along the digitalization journey.

We present the design and evaluation of an MM for PHAs in Germany (the **P**ublic **H**ealth **A**gency **M**aturity **M**odel / PHAMM) that tackles the challenge of harmonizing and improving PHAs' digital maturity, closely involving employees as users in the transformation journey. We developed the PHAMM build-and-evaluate cycles using a coordinated approach among PHA practitioners and governmental stakeholders of more than 15 federal states using four interview studies as well as workshops and a survey. For practice, we offer a MM that is now being used at the national level to coordinate the digitalization of PHAs and to allocate the national funds used by most PHAs to build digitalization projects. For theory, we contribute design knowledge about how this MM can stimulate digitalization for other healthcare organizations and countries with similar organizations. Further, we have adapted Becker et al.'s (2009) procedure model for using MMs in a coordinated approach to defining a vision and detailing steps toward it.

2 Background

2.1 The Digitalization of Public Health Agencies as an Enabler of a Coordinated Crisis Response

Maintaining or increasing public health, as a critical official task of a welfare state (Moran 2000), is delegated to Germany's federal states, which maintain municipal PHAs. Besides fulfilling essential routines (e.g., administering official medical services and doing infection tracking), PHAs serve as central information points, including health promotion (e.g., counseling and educational information about preventive measures for transmittable infections) and care (e.g., providing information on nursing care services to affected persons) (Rechel et al. 2018). Most of these duties have not yet been digitalized, and one reason may be the municipal governance. Yet while many countries offer government services online and digitalize internal processes, numerous voices posit that federal states encounter difficulties accomplishing these tasks (Jaeger 2002; Lee et al. 2005). For instance, Germany has adopted several decentralization principles, such as legislation at the federal level and execution at the local level (Klumpp 2002). The result is an environment with time-consuming decision-making processes and operational process variants that are counterproductive to centralization and its valuable synergies, steering purposes, and efficiency gains (Dunleavy et al. 2006). For instance, a joint digitalization project that integrates government data into a single repository creates a conflict of interests, given the constitutional separation of powers (Jaeger 2002). Similarly, process standardization is challenging, since no dominant actor enforces

standardization movements (Jaeger 2002). Thus, digitalization often takes place in silos, leading to different capabilities in different federal states (Lee et al. 2005), leaving seamless transitions and processes as well as high service quality beyond reach.

With the outbreak of COVID-19, challenges in a federally-managed healthcare system became more apparent than before, such as the need to ensure an aligned approach between federal and state agencies, so that the messages and recommendations conveyed to the public are provided consistently on the same informational basis (RKI 2020). As with other types of crises (e.g., environmental, industrial, natural), the COVID-19 crisis has strongly impacted on society as an "extreme, unexpected or unpredictable event" (Doern et al. 2019, p. 3) that have caused important environmental changes and rapid action at the individual, organizational, and societal levels (Dutton 1986). In addition to routine tasks, health promotion, and care (Rechel et al. 2018), contact tracing of infection cases has become a key issue in preventing the virus from spreading. The associated additional demand on human resources, processing of large numbers of data, and increased communication and coordination efforts with internal and external stakeholders required PHAs to digitally mature and thereby reach a state of digital resilience (Schemmer et al. 2021). Although the concept of resilience is used in psychology, ecology, and economics (Heckmann et al. 2015), we adopt the IS perspective, defining digital resilience as "[…] a phenomen[on] of designing, deploying, and using information systems to quickly recover from or adjust to major disruptions from exogenous shocks." (Boh et al. 2020, p. 1). Regarding the COVID-19 pandemic, the research has focused on specific technologies for building digital resilience, such as digital platforms to maintain a continuous connection to customers (Raj et al. 2023), digital technologies to help firms process and analyze information (Cui et al. 2022), or public health surveillance systems to monitor infection cases (Rai 2020). Instead of addressing specific digital technologies to build the digital resilience of individual PHAs, this work focuses on the digital intra- and inter-organizational transformation to establish a resilient healthcare system.

To build digital resilience and prepare for future crises, the federal and state governments have agreed on a €4 billion pact, of which €800 million is planned to help PHAs digitalize and formulate a set of investment goals (Federal Ministry of Health 2020). Some of these goals relate to an artifact that aims to assess German PHAs' digital maturity and help PHAs increase their digital resilience (Goal 1), reduce structural differences between PHAs (Goal 2), and efficiently allocate national funds (Goal 3). Goal 1 aims to foster the digitalization of 375 PHAs that operate in diverse structural contexts. To meet this goal, two requirements (Reqs) must be met. The artifact allows 375 structurally different PHAs to determine their as-is digital maturity and to mature within digitalization based on this state (Req A). To help PHAs mature through digitalization, detailed practices that can be directly translated into digitalization projects will likely speed up digitalization, since PHAs have not yet gained much experience in defining digitalization practices (Req B). Goal 2 aims to reduce structural differences between PHAs when digitally progressing, and includes two requirements. To reduce structural differences, an approach that supports consensus on a shared digitalization vision on a jointly negotiated basis (Req C) and committing to a defined maturity level in medium-term planning (Req C) helps to harmonize PHAs toward this state. Goal 3 aims to allow the allocation of national funds to facilitate digitalization projects whose efficiencies are then evaluated in retrospect. This goal encompasses two requirements. The artifact functions as the basis for funding for any relevant digitalization project planned by PHAs between 2022 and 2025 (Req E) and assesses the impacts of funding in retrospect (Req F).

2.2 Literature Review of Relevant Digitalization Frameworks

Different digitalization frameworks support organizations in their digital transformation. MMs are one such framework and are widely designed to evaluate an organization's maturity and identify its potentials for improvement (De Bruin et al. 2005; Becker et al. 2009). MMs exist for many domains, including IT management (Becker et al. 2009), knowledge management (e.g., Freeze and Kulkarni 2005), business process management (Rosemann and De Bruin 2005; Hammer 2007), or e-government (Gottschalk 2009). Although there are MMs in the public health field, they mainly refer to specific areas, such as telemedicine (Van Dyk et al. 2012; Otto et al. 2019), hospital processes (Tarhan et al. 2016; Carvalho et al. 2019), or specific digitalization within public health, for instance, cloud security (Akinsanya et al. 2020), healthcare, or infrastructure (HIMSS 2022). Thus, MMs in the public health field have not sufficiently reflected the broad context of PHAs. Since PHAs are integrated into the local structure of public administration, we also consider MMs for e-government – which reflects the government's uses of technology to enhance the access to and the delivery of government services (Layne and Lee 2001) – to be relevant.

Several frameworks for assessing the maturity of e-government have been developed by practitioners, institutions, or researchers (Layne and Lee 2001; Andersen and Henriksen 2006). A recognized MM introduced by Layne and Lee (2001) proposes the digital maturity of e-government as a function of integration and complexity within

four stages. These stages outline the multiperspective change within government structures and functions in the transition toward e-government. Andersen and Henriksen (2006) extended this model by incorporating a customer-centric and technically-oriented approach. Since Layne and Lee's model does not allow for distinguishing between the national and international or the private and public levels, several complementary frameworks and MMs have been developed that consider organizational and national e-government layers (Yildiz 2007; Klievink and Janssen 2009). In 2010, Lee synthesized 12-stage models and developed a five-stage model that combines the citizen and service functions with the technology and operations ones. Over time, classic capability MMs have been adopted from other models in the technological or organizational domains (e.g., Paulk et al. 1993; Rosemann and De Bruin 2005). The Capability Maturity Model (CMM) and the Capability Maturity Model Integration (CMMI) are well known in this category and are also representative of process-centric models (Niazi et al. 2005). As routine processes in PHAs contribute to the performance of e-government, classic MMs appear to be relevant for PHA-specific MMs (Mills et al. 2002).

Since many MMs from the literature are abstract and often have limited applicability, practitioners and researchers have derived practical e-government models and digital assessment tools to help public institutions increase their digital maturity. These models focus on specific countries (e.g., Canada and Australia) and capabilities to deliver services to citizens electronically. The Australian Digital Strategy Toolkit includes four tools that can be used by South Australian departments, agencies, and authorities to self-assess their digital maturity on five levels (South Australian Government 2001). In addition to being descriptive, the model provides an opportunity to identify high-level measures and targets for developing, implementing, and reviewing progress. In contrast, the Government of Canada Interoperability MM (GCIMM) focuses on specifying interoperability goals for government, departments, and agencies to achieve digital maturity for capability areas such as business, information application, and technology at five levels (Government of Canada 2017).

2.3 Shortcomings of Previous Approaches

By reviewing the literature, we recognize that the extents to which e-government structures are implemented are never uniform and strongly depend on national determinants, goals, and contexts (Sarantis et al. 2011). Since PHAs are embedded in specific organizational structures that vary from state to state, MMs must be specific enough to derive concrete recommendations for action (Goal 1, Req C) yet also generic enough to be applicable across 375 different PHAs in different states (Goal 1, Req A). Also, many e-government publications focus on digitalization at the state level but neglect the organizational level (Kafel et al. 2021). Thus, existing MMs are not specific enough to recommend action at the organizational level, where PHAs are embedded in government structures. Further, we recognized that MMs adapted from other domains fall short of practitioners' needs. They are mainly results-oriented and descriptive, and have a limited empirical or theoretical foundation. Although most MMs divide digital capabilities into stages, they do not include a timeline for which maturity level should be achieved at what point in time. Yet a timeline is necessary to ensure that 375 structurally different PHAs approach a similar digital state. While existing e-government toolkits provide practical ways to measure digital maturity via self-assessment, they are limited to one region's specific governmental structure (e.g., Australia) and are therefore hardly transferable to the context of PHAs. As our literature review indicated, no MM or framework has met the specific goals and challenges of Germany's PHAs.

To fill this gap and enable PHAs to mature digitally, we applied a coordinated approach to develop and evaluate an MM for guiding the systematic digitalization of federally-managed PHAs along a manageable timeline. The PHAMM is a framework that helps organizations to understand their current capability level in a specific area, such as project management or IT security; it identifies the steps they need to take to improve and reach a higher maturity level. This approach is suitable for a federally-managed field, because it allows for a coordinated and structured approach to achieving a shared vision within a set timeline, while also offering sufficient flexibility to introduce and implement one's ideas. Further, it helps ensure that all stakeholders are working toward the same goals. The PHAMM provides a framework for assessing the current state of an organization, and identifying the key areas for improvement, as well as a roadmap for implementing changes and measuring progress. By using an MM, organizations can more effectively manage their resources, prioritize their efforts, and make more informed decisions about how to move forward. Because PHAs are part of a federal system, a top-down approach – including for instance directives from the Federal Ministry that all PHAs implement – cannot be used. Instead, digitalizing federally-managed PHAs requires a bottom-up approach that allows for negotiating a target state of digitalization and considers a PHA's diverse intra-organizational structures, digital prerequisites, and available resources. Allowing for a maturity level analysis to measure digital maturity in diverse areas (e.g., IT security management), MMs render digital maturity measurable and quantifiable

for every PHA (Lasrado et al. 2015). The interplays between the homogenization of heterogeneous PHAs and flexibility is a prerequisite for achieving intra- and inter-organizational harmonization on different levels (e.g., IT security, IT infrastructure, interoperability). Only when these conditions are met can digital resilience be possible through digital maturity in a federal system. To make the PHAMM as simple and user-friendly as possible to use in practice, we decided to operationalize it as a practical assessment tool, analogous to the Australian Digital Strategy Toolkit (South Australian Government 2001).

3 Method

This work follows the design science paradigm. Within it, several methods have emerged that guide authors in designing their artifacts. This work follows the methods of Kuechler and Vaishnavi (2008), and Sonnenberg and Vom Brocke (2012), which include the steps *awareness of the problem*, *suggestion* of a solution, *build-and-evaluate cycles*, and *conclusion*. As we contribute an MM, these steps are informed by the procedure model for MM development (Becker et al. 2009). Figure 1 provides an overview over the PHAMM and its integration into design science. Developing a MM requires eight stages, starting with 1) problem definition, 2) comparing previous MMs, 3) determining the development strategy, 4) iterative MM development, implementation, evaluation, and the decision to apply or reject the MM (Stages 4 to 8) Becker et al. 2009). Within the stages, as we will now describe, we applied different methods, for instance, a literature study, interviews, and observations. Because the resulting MM guides the digitalization of PHAs, we called it the Public Health Authority Maturity Model (PHAMM).

Literature study (Stages 1–3): Beyond problem definition and suggestion (see introduction and background), this literature study reviewed MMs to analyze components of MMs regarding their fit to the PHAMM and to develop the interview guideline. The details of the review procedure and a chart of the search results appear in online Appendix 1 (available online via http://link.springer.com). As previous research discussed digitalization within administration and healthcare, and has provided evidence to predefine the dimensions and to inform the interview guideline, we specified the development strategy (Stage 3) as a top-down approach. In line with this, we extracted potentially relevant dimensions and questions to help define criteria within the dimensions. We decided on a continuous (vs. a staged) MM representation, because it suggests practices for several areas (Chrissis et al. 2011). In each area, practices of consecutive maturity levels build on one another and support guidance. For instance, planning IT-supported cooperation across PHA departments fosters cooperation at a low level. An intermediate level foresees implementing cooperation among first units, while a higher level concludes these practices by suggesting implementing cooperation among any organizational unit for which it is helpful.

Interviews (Stage 4): After formulating the development strategy, we iteratively developed the PHAMM through three interview rounds. We conducted semi-structured interviews following qualitative research techniques. We did the theoretical sampling for data collection according to Corbin and Strauss (2008). Thus, we did not determine all interviewees in advance but selected suitable persons in the research process. For instance, during the initial interviews, we heard that PHAs have different tasks and are subject to different legal requirements in different federal states. So, we integrated interviewees from different federal states to identify the commonalities and differences between the PHAs. An overview over the institutions included in the interviews appears in Appendix 2. We invited the interviewees for a one-hour interview via video-conference. After each interview, one author coded the interview material, and another checked the results, to resolve misunderstandings. In the beginning, we worked with open, inductive codes (Corbin and Strauss 2008). With an increasing number of interview data, we developed the codes until a level of abstraction emerged in which the codes became the practices, subdimensions, and dimensions. We describe the changes in the codes due to the increasing analysis and number of interviews with an example in online Appendix 2.

In **interview round 1**, we conducted 15 interviews with 22 experts from federal state ministries of health, higher-level public health organizations and projects, IT service providers, and nongovernmental organizations. This round helped gather the digitalization contexts of PHAs, define the scope, and negotiate an achievable maturity level. In **interview round 2,** we conducted 15 interviews with 21 practitioners from PHAs with varying digital maturity levels. This enabled learning from well-developed PHAs about their path to becoming digital and less developed PHAs to identify barriers. For instance, we gained insights into barriers among employees who hardly participated in digitalization, leading to the dimension *employee participation*. After interview rounds 1 and 2, the authors organized a workshop to cluster practices into (sub)dimensions. If different options arose, the authors discussed them and decided on one option. Two authors then assigned practices to the maturity levels in an open card sorting. We subsequently obtained the PHAMM 0.8 with eight dimensions and 27 subdimensions, with practices assigned to five maturity levels. **Interview round 3** included 15 interviews with 18 PHA practitioners. For this round, we adapted our

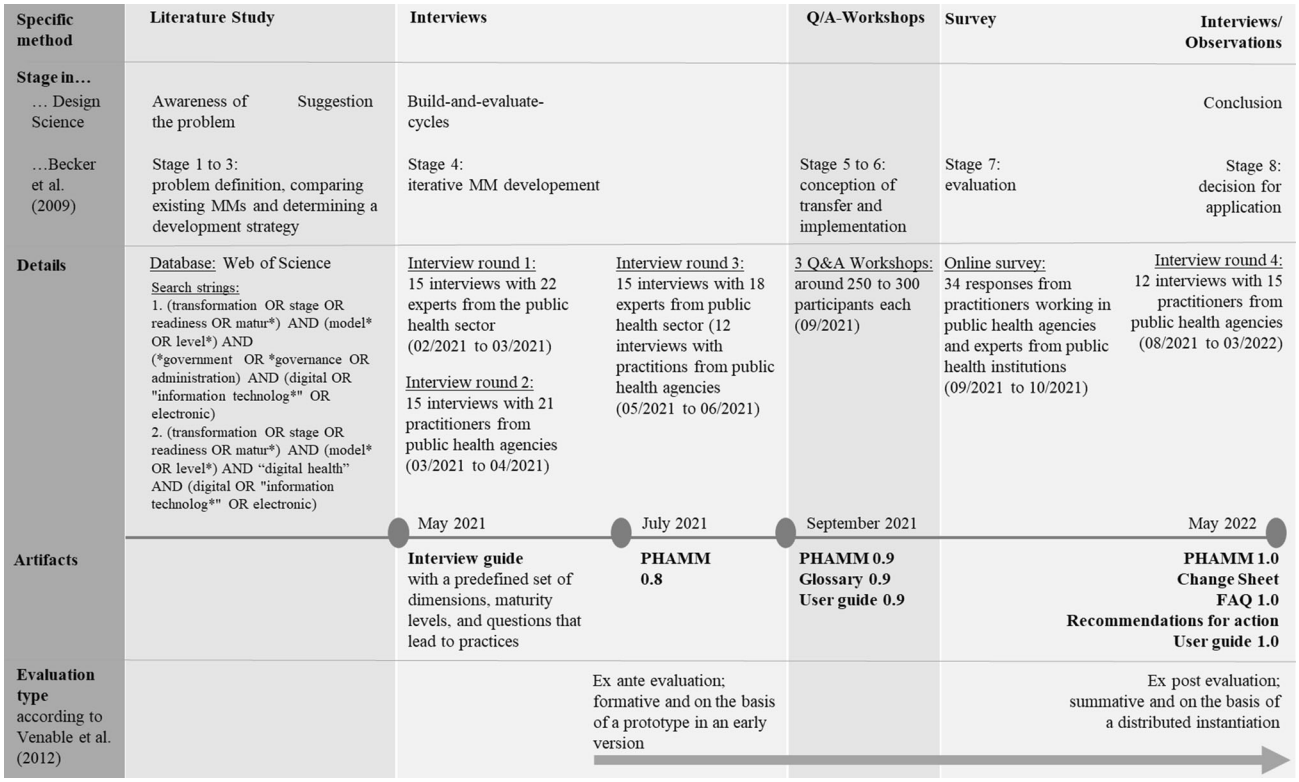

Fig. 1 Methods used in the development of the public health agency maturity model

interview guide based on the previous interviews. For instance, when the subdimension employee participation emerged, we asked each interviewee what role this topic played for them. We also included an Excel-based PHAMM and asked the interviewees to reassign or integrate new practices or alter the description.

Q&A Workshops (Stages 5–6): Aiming to transfer the MM to the target audience (Stages 5–6), we published PHAMM 0.9 and enabling documents (user guide, glossary) through a national mailing list. Further, we conducted three question-and-answer (Q&A) workshops to help people understand the PHAMM and invited participation in a survey. Each workshop included around 250–300 participants. At the start of the workshop, we introduced the PHAMM, explained its application, and then did a Q&A. Questions and answers were recorded and informed the interview guide for the upcoming evaluations and to develop an FAQ section.

Survey (Stage 7.1): We started the evaluation with a survey to examine usability, completeness, and appropriate step size between maturity levels. Of about 375 PHAs invited to participate, 34 responded to the survey (a 9.1% response rate). Details of the study design and results appear in online Appendix 3. We used responses to open-ended questions (e.g., *Please provide a brief explanation if you think that one or more of the dimensions were not fully captured*) to improve the MM.

Interviews (Stage 7.2): We conducted 12 observation interviews with 15 PHA practitioners to evaluate the PHAMM's application. Participants were instructed to think aloud while applying the MM (Fonteyn et al. 1993). We then asked the participants about their impressions of the model's applicability and completeness. The interviews led to refining the terminology so as to increase understanding and user-centeredness. For instance, we added additional terms to a glossary (e.g., criticality, level of abstraction), removed redundant practices, and separated overly complex practices. Further, discussions with the interviewees pointed out that the PHAMM helps achieve digitalization maturity within PHAs. Regarding applicability, the practitioners appreciated the progression of practices along maturity levels. For comprehensiveness, they confirmed that the PHAMM covers the critical dimensions that act as focus areas for digitalization within their PHAs. Regarding assigning the practices to maturity levels, they proposed a few adaptations but confirmed the assignment generally. Regarding consistency, they acknowledged that the practices mature along the maturity levels and concerning problem adequacy. They also confirmed the ability of our research to help PHAs to digitally mature.

4 The public Health Authorities Maturity Model (PHAMM)

The PHAMM seeks to increase federally-managed PHAs' digital maturity. The federally-organized public health sector faces several challenges that hinder a shared digital maturity endeavor. These challenges induce specific goals and requirements (Reqs) that are now addressed in the PHAMM (for a summary, see Table 1). Based on interview rounds 1 and 2, we formulated solutions to meet these goals and requirements. For instance, to reach Goal 1, we included many structural different PHAs that aim to mature by digitalizing (Req1.1) and to derive concrete digitalization projects (Req1.2). To meet Req1.1, we formulated practices as abstract as necessary so as to allow the digitalization of all PHAs. We also formulated a mechanism that enables a PHA to omit practices if they do not fit its context. To abstract the practices, we included a wide range of interviewees, such as PHA managers and referees of federal governments. Analogous to the example above, we formulated further solutions in the PHAMM (see Table 1). Having summarized requirements and implementation decisions, we will now introduce the artifact. The PHAMM has a matrix structure with eight dimensions on the vertical axis. Each dimension includes two to five subdimensions, which help categorize the practices. The horizontal axis arranges the practices into five maturity levels.

5 The PHAMM's Dimensions of Digitalization

The PHAMM's dimensions were informed by previous research as well as interviews. To identify the dimensions for PHA digitalization, we first examined the relevant practical evaluation toolkits from different countries (South Australian Government 2001; Government of Canada 2017). The models provided valuable insights, especially for the dimensions *digitalization strategy*, *software*, *data*, *interoperability*, and *employees*, which we enriched with the inputs of other e-government MMs and from the interview rounds. Table 2 summarizes the PHAMM dimensions for digitalization.

The **digitalization strategy** forms the overarching roadmap for PHA digitalization and defines an action plan to implement digitalization projects derived from the PHAMM. In particular, the need to fuse IT and business strategy has been articulated in the strategy literature (Teubner and Stockhinger 2020). Further, organizational success depends on the interplays between strategy, IT, and IT governance (Tai et al. 2019; Chau et al. 2020). The digital maturity in this dimension develops for instance from defining a digital strategy (low maturity level) to operationalizing the strategy into concrete digitalization projects (intermediate level) toward aligning with other PHAs on the digital target state and planned digitalization projects (high level). Thus, this dimension differentiates between the PHA's focused view of first theoretically arriving at a strategy toward implementing it and, at the highest level, collaborating with other PHAs on developing the strategy in light of nationwide political development and aligning digitalization projects. In this regard, one interviewee mentioned: "What is needed [in terms of sustainable digitalization] is a farsighted view on the effects of policies, and also [PHAs'] participation in the overarching development of goals at the state level – a nationwide IT strategy would be ideal, but this is problematic owing to federal structures."

Active **employee** involvement is imperative if digitalization is to be successful. Workforce capabilities are a crucial part of digital transformation processes (Rueckel et al. 2020), and the research has hinted at employee connectedness being key for creating a digital workplace (Dery et al. 2017). In line with this, our interview results show that digital maturity in this dimension evolves from involving single employees in defining and implementing digitalization projects (low maturity level), to implementing a dedicated digitalization contractor who acts as a multiplier within the PHA to foster digitalization projects and convince other employees that these projects' results improve their daily work (intermediate maturity level), to PHAs setting up dedicated training concepts for employees to increase their digital literacy (high maturity level). Besides a top-down digital strategy, this bottom-up effort is necessary to loop employees in the transformation process. A participant stated that the "digitalization processes must be incorporated in such a way that employees are empowered to both live digitalization and to acquire the knowledge to do so."

Process digitalization requires understanding all the PHA processes as a whole and establishing ways to digitally improve them. Accordingly, this dimension can be separated into documenting processes as a starting point for re-engineering and evaluating the level of reasonable IT based on the processes. An interviewee stated: "[The first step is] to think about suitable processes […] and, if desired, to generate requirements from them." Documented processes help to communicate internal workflows with external stakeholders, such as software providers (Nancy et al. 2016). Most PHAs face a low maturity level in a historically grown heterogeneous process landscape that solves the same tasks with completely different processes. Thus, a holistic information flow across various PHA departments with seamless interfaces between the subprocesses across departments and other organizations is required but not implemented. The crisis has shown that nondigitally-supported data transfer leads to a high manual

Table 1 Summary of the goals, requirements, and the implementation of requirements within the PHAMM

Overall goal	Goals	Challenges in public healthcare	Requirements	Solutions within the PHAMM	Empirical basis (Imp = implication decision)
Allow for defining a jointly negotiated digitalization goal for PHAs and differentiating steps toward this goal	Goal 1: Applicability for many federally structured PHAs to increase digital resilience	PHAs differ regarding administrative structure, financial and personal resources, and as-is digital maturity	Many structurally different and independent organizations can mature through digitalization using the PHAMM	Practices are formulated as abstractly as necessary to allow the digitalization of all PHAs Deciding for an 80:20 mechanism that allows PHAs to reach a maturity level for a subdimension if at least 80% of the practices are fulfilled. This mechanism allows for more flexibility, for instance, if a particular practice does not fit a PHA's structural context	Imp1: Suggestions by interviewees in rounds 1 and 2, so that all PHAs can exploit the PHAMM's potentials Imp2: A result of discussions with the Federal Ministry of Health about different mechanisms, including a general scoring across all dimensions and a differentiation between *must-have* and *can-do* practices
		PHAs lack digitalization experts. With the pressure induced by crisis, PHAs need detailed best practices on what to do and how	Practices are detailed enough to derive concrete digitalization projects	Practices considered too abstract to derive digitalization projects are detailed with concrete recommendations for actions in an enabling document accompanying the PHAMM. Future research foresees developing the PHAMM as a living MM that PHAs can use to add concrete recommendations for action for their specific context after completing their digitalization project	Imp3: Interview rounds 1 and 2 helped to detail practices and concrete recommendations for action. Round 3 helped to refine and enrich these recommendations for action
	Goal 2: Reduce structural differences between PHAs	PHAs have no shared vision toward their to-be digital maturity	Determining a shared vision among many PHAs	A vision was derived throughout the interviews to develop the PHAMM. Based on this vision, it was determined what can be reached at the highest maturity level (level 4)	Imp4: What was desirable and doable for maturity level 4 was defined with interviewees in rounds 1 and 2 and was refined with interviewees in round 3
		Digital interoperability between PHAs is not possible owing to the lack of a standardized digital infrastructure	Committing to a shared maturity level that PHAs should target in medium-term planning	The PHAMM is serving as a coordination tool between referees at the national and the federal levels to commit to a shared maturity level that PHAs are recommended to reach by 2025	Imp5: A shared maturity level that PHAs are recommended to reach by 2025 was defined outside the research based on a political decision-making process
	Goal 3: Allow for the allocation of national funds at the federal level	Public funding should be used in very targeted ways for a specific goal	Funding can be applied for all relevant digitalization projects planned by PHAs for 2022 to 2025	Practices need to be evaluated regarding the completeness of potentially relevant digitalization projects and toward a sufficient level of detail, so that any need for funding for a particular digitalization project can be specified with the PHAMM. Further, the step width between maturity levels is appropriate and allows for defining an appropriate funding proposal	Imp6: Practices were evaluated and refined regarding completeness with interviewees in rounds 3 and 4
		Public organizations must report on achievements through public funding	The impacts of national funding can be assessed in retrospect	The PHAMM can be used to assess whether funding has led to digital maturity using annual follow-up evaluations	Imp7: The PHAMM was evaluated and refined for an assessment of PHAs' digital maturity in round 4

Table 2 Dimensions of the PHAMM

Dimension	Description, including **subdimension**
Digitalization strategy	The dimension *digitalization strategy* comprises (1) **the definition, communication, and implementation** of the digitalization strategy, the (2) **definition of responsibilities**, and the planning of the necessary (3) **digitalization budget** for the PHAs' tasks and objectives
Employees	The dimension *employees* includes the (1) **sensitization** and (2) **participation** of the employees in digitalization activities, as well as the aspects of (3) **training** possibilities
Process digitalization	The dimension *process digitalization* includes: the extent to which processes are (1) **documented**, the extent to which processes are (2) **IT-supported**, and the extent to which there are (3) **overlapping processes** to be addressed via cross-process coordination. Finally, we lay out criteria for the (4) **evaluation of processes** across tasks and departments
IT security	The dimension *IT security* includes the scope of (1) **IT security management**. It also addresses concrete measures for (2) **dealing with IT security risks and attacks** as well as (3) **identity and access management**
IT provision	The dimension *IT provision* includes the equipment of the (1) **IT workplace** (hardware and operating systems), the (2) **organization of the IT procurement** and of the (3) **IT infrastructure**, and the (4) **application of IT service processes**
Citizen focus	The dimension *citizen focus* includes the consideration of the (1) **interaction** with citizens and orientation and design of the available information (2) **preferences**
Cooperation	The dimension *cooperation* includes (1) **cooperation within the public health departments**, (2) **cooperation between health departments among themselves and with provincial offices**, and (3) **cooperation with external stakeholders**
Software, data, and interoperability	The dimension *software, data, and interoperability* includes the (1) **use of specialist applications** as well as their (2) **technical interoperability**, (3) **data analysis and reporting**, (4) **requirements and documentation** of specialist applications, and (5) the **protection of data**

workload when transferring paper-based data into IT systems or between systems without suitable interfaces. The PHAMM outlines steps across end-to-end process documentation and visibility (low maturity level), to process simplification and standardization (intermediate level), to continuous evaluation and identification of opportunities for improvement (high level) (Mendling and Jans 2021), for instance through the use of key performance indicators (Esswein et al. 2008). IT systems are integrated for data transmission, error control, and simplified communication across departments and organizations, levering standardized interfaces.

A high **IT** and data **security** level is a prerequisite for PHA digitalization owing to the need to protect personal health data. To ensure the primary protection goals of information security, confidentiality, integrity, and availability (McLaughlin and Gogan 2018), standards must be adhered to. First, there are technical guidelines on cryptographic procedures specified in ISO 27001. Second, there are country-specific basic protection compendia that contain instructions, recommendations, and measures regarding the conformity of authorities' requirements. In our interviews, German IT security experts stressed the need to dismantle insular solutions and the need to adhere to standards despite operating in a federal system since the specification catalogs are usually vast and PHAs lag behind the requirements. However, as a current IS security literature review shows, we lack a holistic view of system design and vulnerabilities (Dhillon et al. 2021). In the PHAMM, we overcome this by offering key high-level indicators and concrete measures for dealing with IT security risks and attacks as well as identity and access management. On a low digital maturity level, all IT security standards thar are required by law are adhered to. On an intermediate level, IT security management is individualized to the PHA's environment. On a high level, IT security management is continually adapted to changing PHA requirements. Further, there is a high awareness among all employees on how to minimize IT security risks.

The dimension **IT provision** includes the equipment of stationary and mobile workplaces, the procurement of IT infrastructure, the organization of IT equipment, and IT service processes. Based on a needs analysis regarding the employees' expectations of their IT workplace, concepts and strategies can be developed to achieve (1) a state of sufficient equipment for the stationary and mobile IT workplaces, (2) the efficient organization of the IT equipment, and (3) the appropriate application of the IT service processes. The PHAMM differentiates between the provision of basic IT equipment within a PHA on a lower maturity level and the availability of equipment for remote work on an intermediate level, specifying hardware and software for a hybrid collaboration that is continually adapted to new ways of working on a higher level. A mix of participative and directive measures has proven effective in de-complicating workflows: This includes involving

users in the implementation process through training and consultation as well as through developing an implementation plan that addresses potential resistance scenarios (Harris and Weistroffer 2009). For instance, ITIL describes a best practice guide and standard in the IT service management area (Wulf and Winkler 2019).

Citizen focus means aligning processes and activities holistically with citizens' needs. Yet administrative institutions face no direct competition when serving the common good. To still reach a sufficient citizen focus, the design approach in the public sector should be democratic (Olphert and Damodaran 2007). On a lower maturity level, basic digital interaction channels (e.g., e-mail, forms) are available to citizens. On an intermediate level, digital two-way communication is made possible, while on a high level, the PHAs have a multichannel strategy and provide corresponding IT support. Ideally, citizens are involved in all decision-making stages, from agenda-setting to technology development, and implementation to evaluation. Further, a mix of online and offline services (e.g., counseling services via video or in-person) helps to consider citizens' preferences about ways of interacting and incorporates feedback mechanisms. An interviewee pointed out that "being digital is a trend and a desire. That's the viable path. But not all [citizens] are digitally active; you have to consider the needs of both citizens with and those without an affinity for technology, that is, the users."

PHAs consist of several departments and must ensure **cooperation** between the departments. Further, PHAs must cooperate with other PHAs, provincial offices, state agencies, and other external stakeholders such as courts and hospitals. A central criterion of the cooperation subdimension within the PHA is the IT-supported collaboration of any PHA department with mutual digitalization potential through defined interfaces for data exchange and common exchange formats. This approach is reminiscent of Jeff Bezos's 2002 mandate at Amazon, which underpins the current API design philosophy within the company. In accordance with this philosophy, teams are encouraged to expose data and functionality through service interfaces and communicate with each other through these interfaces (Rosoff 2011). The PHAMM explicates the different levels toward seamless cooperation. At a lower level, communication between departments is digitalized but not further structured. Digital maturity increases at the intermediate level through harmonized technical and semantic data exchange standards. At a higher level, collaboration within a PHA and with other organizations occurs through knowledge and collaboration platforms.

The dimension **software, data, and interoperability** includes the use of specialized applications and their interoperability, data analysis, documentation of specialized applications, and data protection. It reflects the software-side core of the digitalization process and sheds light on the meaningful use of software. There are both functional requirements (e.g., the possibilities for cross-institutional data exchange, for instance for infection control) and nonfunctional ones (e.g., data privacy issues). On a low maturity level, PHAs use several different applications to perform their business processes. An interviewee stated: "Our work on cross-interface tasks is tedious and unsatisfying, because it is actually the exception that these interfaces do work." On an intermediate level, short-term solutions such as gateways can provide quick solutions for still-missing bidirectional interfaces. On a higher level, the need for modular possibilities for creating lightweight digital solutions (e.g., the integration of chatbots) and a legally compliant e-filing system has been raised repeatedly.

6 PHAMM Maturity Levels

The PHAMM has five maturity levels, ranging from level 0 to 4. Level 4 describes the digital maturity goal for PHAs. Having implemented practices of this and the preceding maturity levels allows PHAs to reach their goal. As this is a complex endeavor, maturity levels 0 to 4 aim at a step-wise development of capabilities that lead to the goal once the successive practices of the different maturity levels have been implemented. Most practices organized within the maturity levels of one subdimension build on one another, so implementing a practice at a lower level is a condition for further progress. For instance, the dimension digitalization strategy defines an action plan to implement digitalization measures. While the planning of such an action plan occurs at maturity level 0, it conforms to the federal and state governments' legal requirements and includes specific digitalization projects at maturity level 1. Level 2 further foresees a well-documented action plan that is accessible to PHA employees, and that is evaluated annually regarding pre-set goals. Level 3 further demands a biannual evaluation and concrete actions derived for any PHA department. At level 4, PHAs exchange their experience to develop an action plan and help PHAs at a lower maturity level to develop this capability. In line with this example, maturity level 0 generally triggers planning an action, while level 4 usually involves sharing the results with others, the continuous evaluation of achieved capabilities, and adaptation to current best practices. The intermediate maturity levels (1–3) describe transitory levels that support the step-wise character of capability development.

7 Application of the PHAMM

Using the PHAMM for digitalizing PHAs requires several steps. First, PHA managers need to identify their as-is digital maturity by declaring the fulfilled practices that have been implemented. To account for differences between the 375 PHAs, at least 80% of a maturity level's practices must be fulfilled for a dimension. This mechanism allows PHAs to flexibly choose practices that fit their demands (see Solution II in Table 1). Second, after determining the as-is digital maturity, PHA managers specify the to-be digital maturity, which is operationalized by prioritizing practices for implementation in the near, intermediate, and later future and for formulating digitalization projects. As the PHAMM only contains information about dimensions, subdimensions, maturity levels, and practices, we specified the procedure to apply it in enabling accompanying material. For instance, one document specifies how practices defined on an abstract level can be used to define concrete digitalization projects. Further, a user guide details the application process, for instance, including multiple stakeholders such as IT providers or specialists operating in regional authorities to specify the as-is maturity if a PHA needs help. Further documents include a glossary, which aims to facilitate a shared understanding of and instruction on how practices can be prioritized based on the PHAMM, and an FAQ section. The PHAMM (including accompanying documents and materials) is provided on the website of the Federal Ministry of Health.

8 Discussion and Contributions

Using a joint negotiation process that included many stakeholders from the public health sector, we have developed and evaluated the PHAMM for federally-managed PHAs in Germany to digitally mature so that employees have the right organizational support when managing upcoming potential crises. The PHAMM has three primary components: (1) Eight dimensions with subdimensions that structure the application areas of digitalization, (2) more than 350 practices assigned to the five maturity levels of each dimension, and (3) guiding material, including concrete digitalization projects. Drawing on the literatures on e-government and on MMs, we developed and evaluated the PHAMM in iterative build-and-evaluate cycles, including practitioners' insights from four interview rounds, including 57 individual interviews, three workshops with 250 to 300 participants each, and an online survey with 34 expert responses. The resulting eight dimensions of the PHAMM holistically define PHAs' focus areas of digitalization along specific subdimensions and along five maturity levels in an organizational cross-section. Being a continuous MM, the PHAMM adds to prescriptive knowledge on maturing digitalization in PHAs. Defined as actionable practices that mature along the various levels, the practices reflect insights from research and practice, providing prescriptive knowledge on how to develop from the lowest to the highest maturity level.

With its context-related design, the PHAMM addresses the overall goal of allowing for a negotiated approach to define a target digitalization state for PHAs, differentiating steps toward this state. The PHAMM also addresses three further goals, given the context of the PHAs operating in a federal system: (1) applicability for many federally structured public institutions, (2) reduction of structural differences and harmonization among organizations when progressing within the PHAMM, (3) budget allocation to the PHAs. With its distinct practices, the PHAMM seeks to balance being applicable in a context of diverse structural requirements, where a sound, sober as-is analysis of digital maturity is needed, as is actionability for realizing *quick-wins* in a crisis context. Thus, the PHAMM seeks to overcome weaknesses in de-centralized governance approaches that have primarily been associated with weaker performance (Denford et al. 2020).

Addressing the abovementioned goals, the PHAMM seeks to tackle the lack of digitalization in PHAs and focuses on the digital intra- and inter-organizational transformation to establish a resilient healthcare system so that they can respond to citizens' needs, even in crisis situations. Following this endeavor likely allows for digitalizing related areas and institutions, since Germany's PHAs are embedded within local governments. For instance, PHAMM criteria within the dimensions of IT security and IT provision also address building digital capabilities in the local governments where PHAs are embedded. Building digital capacities in these structures will likely benefit other areas that fall under these local governments, such as youth welfare offices, integration offices, and social security. Further, the institutions in Germany's public health sector cooperate closely; for instance, laboratories share diagnostic results with PHAs, and PHAs share both data regarding COVID-19 spreading events and participants with other PHAs. Thus, adhering to the PHAMM criteria likely spreads interoperability to other public health institutions.

8.1 Implications for the Application of Maturity Models

Typically, MMs aim to build an understanding of the as-is and to-be digital maturity of one or a few organizations that operate in similar contexts (Becker et al. 2009; Pöppelbuß and Röglinger 2011; Blondiau et al. 2016). This work

shows additional usage cases for MMs, i.e., that MMs can serve as an instrument for decentralized organizations to define a goal along with steps toward it in a negotiation approach and for resource allocation.

8.1.1 A Maturity Model as an Instrument to Jointly Negotiate Goals and Steps Toward Them:

This work has demonstrated how MMs can be used to negotiate goals and steps toward them in a federal setting. In federal settings, a top-down decision-making approach is not applicable to achieve a centralized and shared goal, which is necessary to ensure the digital resilience of the public health sector. The PHAMM, as part of a democratic negotiation process, fosters the necessary discussions that will lead to a commitment by institutions operating at different levels within the federal system to take the necessary actions. It supports the negotiation process, since it reflects the overall goal (the highest maturity level) and the steps toward achieving it. The PHAMM provides the structures to agree on fixed requirements and leaves room for individual realization approaches. In turn, the joint commitment of involved parties can promote trust in the system's institutional arrangement and citizens' trust by setting out a transparent path that addresses institution-specific requirements.

8.1.2 MMs as an Instrument for Resource Allocation:

The PHAMM is being used to distribute national funds of €800 million for digitalizing the PHAs (Federal Ministry of Health 2020), out of a €4 billion package. Thus, the PHAMM both seeks to help PHAs to digitalize by providing concrete practices and needs to allow for the distribution of national funds so that PHAs have the means to implement these practices. In the next years, the resource allocation and its impacts on digital progress within the PHAMM will be evaluated. Such evaluations may help to further adapt MMs for the goal of resource allocation. To allow us to use MMs for a negotiated approach and resource allocation required that we adapt Becker et al.'s (2009) procedure model. We will now elaborate on the implications of MM development.

9 Implications for the Development of Maturity Models

Besides having implications for MM application, this work has contributed to the literature on MM development by integrating a wide variety of stakeholders in a mixed-method approach to jointly negotiate a digitalization goal and steps toward it, developing an MM utilized by more than 350 organizations. However, Becker et al.'s (2009) MM development process neither foresees a negotiation approach required for consensus-building in the federal field, nor addresses MM development for multiple organizations. Since such an approach is appropriate for many digitalization endeavors in federal systems (e.g., education, disaster protection), we formulated adaptation potentials and our lessons learned for the procedure model of Becker et al. (2009) in Table s. We will now explicate the main adaptations and refinements. According to Becker et al. (2009), MM development has eight stages, starting with problem definition (Stage 1), comparing previous MM research (2), determining the development strategy (3), and then continuing with an iterative MM development, implementation, evaluation, and refinement or rejection (Stages 4–8). For determining the development strategy (Stage 3), in the context of many prospective organizations using an MM, the top-down development strategy aiming for a continuous MM is recommended (Becker et al. 2009). Continuous MMs show how practices evolve across maturity levels and outline the maturation path. For Stage 4 – iterative MM development – we combined inductive and deductive design approaches in highly iterative build-and-evaluate cycles with many touchpoints with relevant stakeholders. To achieve this, various methods of gathering requirements (such as interviews and workshops) were implemented, a broad range of stakeholders were involved in the process, and both timely and ongoing forms of evaluation were utilized.

Regarding Stage 5 – the conception of transfer and evaluation – the large range of prospective users must be considered. Thus, the transfer media had to allow for high scalability and accessibility so as to ensure applicability to all 375 PHAs. Further, the evaluation must integrate a diverse set of PHAs to account for most of the specifics (Stage 7). To enable all PHAs to successfully use the MM, we adapted the procedure model and expanded Stage 6 with enablement activities. We organized three workshops for all PHAs and accompanying enablement material for the PHAs using the PHAMM. This allowed for direct feedback from the PHAs and from Q&A sessions. We used both to evaluate and improve the enablement material. With the objective to continually improve the PHAMM and account for changing requirements, the application of the PHAMM is scientifically accompanied (Stage 8). These refinements and learnings can be applied to other MM development contexts.

10 Generalizability of the PHAMM

Beyond using the learnings of this work for developing future MMs for other areas of federal systems, we argue that parts of the PHAMM can be subject to a broader type

Table 3 Refinement and learnings during Becker et al.'s (2009) procedure model for the development of maturity models

Stage	Objective	Actions	Learnings
1	Problem definition	Digitalization of the public sector. Organizations to build digital resilience	The context adds additional requirements toward MM
2	Literature review	MM in e-government MM in a specific sector	–
3	Determine the development strategy	*Top-down approach*: First determine the generic maturity stages and assign practices to them *Continuous MM*: Outline the maturation path along the maturity level	Continuous MM provides organizations with a low level of experience regarding a clear maturation path
4	Iterative MM development	Inductive and deductive MM development *Punctual elements* of generating inductive insights: three interview rounds with a broad set of interviewees *Continuous elements* of evaluation of the current MM: Weekly workshops with the Federal Ministry of Health, monthly workshops with federal-state health authorities	Combine punctuality with continuous elements, highly intertwined with relevant stakeholders: Overview over structural differences between organizations Required engineering of different organizations Setting a shared and achievable digitalization vision
5	The conception of transfer and evaluation	Evaluation with a broad range of PHAs owing to differences regarding structure, maturity, and boundary conditions	Transfer must be scalable and self-explanatory for the application of an MM Evaluation must be conceptualized for a broad range of prospective users, ranging from low-level digitalization expertise to expert knowledge
6	Implementation of the transfer media and Enablement	Implementation of the PHAMM via the website; enabling PHAs includes workshops, supportive material (documents, videos), and an FAQ section	Implementation must support the continuous use of MMs Transfer must be complemented with dedicated enablement sessions –Enablement via documents and material and face-to-face workshops to enable Q&A
7	Evaluation	Evaluation survey, workshops with the federal and national governments, pre-testing, application of the PHAMM	Different evaluation types: Survey for broad feedback Interviews for more detailed feedback Application with subsequent interviews
8	Refine or reject the MM	Ongoing development: living the MM	Scientific evaluation concept throughout the application of MMs

of generalization. For instance, the public health sector's attributes – decentralized, federalized, different resource availabilities, and low digitalization knowledge – are also valid for other parts of the public sector, for instance, citizen services, universities, schools, and employment services (Olphert and Damodaran 2007). Looking ahead, it is critical that the public sector to participate in data-oriented value creation, which is a key driver of the digital economy (Alaimo et al. 2020). However, this integration is only possible if processes, the uses of technology, and the organization of work are adapted or even redesigned accordingly; such efforts' success must then be determined through suitable instruments that bridge national strategies and federally independent institutions.

At the international level, the COVID-19 pandemic demonstrated the need for multiple institutions to collaborate, not only in Germany but also in other European and non-European countries, making interoperability among public sector organizations essential to managing the crisis (Cui et al. 2022). For instance, within German and European initiatives, the importance of public data for researching and managing COVID-19 and other pandemics continues to grow, and PHAs will have a central role in collecting and using data in the future (Büttner-Thiel et al. 2022). The PHAMM allows for transferability to other countries, with minor adjustments of the procedures to national specifics as necessary. In the private sector, organizations typically face very close collaboration when they work together in one supply chain, or when they are business units spread across several countries and belong to one organization. While in these cases, the business units act autonomously, group-level transparency across the decentralized units may be missing, since there are likely challenges between team autonomy and the need for coherence in the wider system (Ravn et al. 2022). With the aim of standardizing digitalization maturity across business

levels or enabling interoperability between units, the PHAMM dimensions can be a starting point to define a shared aspiration level. The practices still need adaptation, depending on an MM's overall objective.

11 Limitations and Future Research

We present limitations, complementing them with possible avenues for future research. First, the PHAMM builds on a literature review, accounting for mature knowledge from seminal work in the context of the digitalization of public health sector organizations. Although we did not include all articles in our in-depth screening, we considered a broad range. We are confident that no other MM has been developed as yet for the context at hand. Second, the PHAMM was designed to help 375 PHAs to digitally mature. Since the PHAs differed in context and structure, we involved a broad range of PHAs in the build-and-evaluate cycles. Although we invited all PHAs at different steps of the procedure model, not every organization participated. We are nonetheless confident that the PHAMM is generalizable to all PHAs based on our sampling strategy for the interview rounds and our evaluation methods. Third, based on interview round 1, we derived practices for digitalization maturity and did a card sorting to assign the practices within one dimension to the subdimensions and maturity stages. Although we did not do a closed card sorting to derive a metric for reliability, the empirical validation (interview round 2 and evaluation) confirmed that the proposed assignment provides a reliable indication of the maturity stage in which the practice is implemented. However, future research could do the closed card sorting in a broader survey that includes additional academics and practitioners.

The digitalization of PHAs, with their many stakeholders, is a very complex topic. The PHAMM reduces this complexity. Such a reduction may not lead to satisfactory solutions for every area, and may have missed relevant aspects of digitalizing PHAs, prompting future challenges. As part of a scientific evaluation of the PHAMM in the future, we will also analyze in-depth what the PHAMM may have missed and how this can be addressed in a future iteration. Future research may also seek to develop the PHAMM's dimensions and/or the PHAMM as a tool. For developing the PHAMM's dimensions, the interview data indicated that including recommendations on single dimensions could improve the PHAMM's digitalization effects (e.g., a more agile project organization in the dimension digitalization strategy, in line with Matook et al. 2016), or software orchestration for the better mobilization and coordination of the creation and deployment of software, in line with Maruping and Matook 2020). For the further development of the PHAMM as a tool, we will investigate the completeness of digital capabilities and will, if necessary, enrich the PHAMM with practices. Further, we will examine whether the maturity levels' step sizes are appropriate to facilitate digitalization. For instance, if reaching the next maturity level would require digitalization projects that require too much effort, they may be avoided, and a progression within the MM for this particular capability may be inhibited. In this case, reallocating practices to other maturity levels may lower the step size and may motivate PHAs to define digitalization projects in a way that facilitates progress within the PHAMM for all capability areas. Many interviewees also supported the development of the PHAMM as a knowledge platform where PHAs can exchange experiences about digitalization projects defined based on the practices. Thus, the PHAMM may be used to add recommendations for specific digitalization projects, comment on these recommendations, and refine them for diverse contexts.

12 Conclusion

Despite both the great need and potentials for applying MMs for digitalizing PHAs, these opportunities have not yet been fully seized in the IS research. We have presented the PHAMM as an instrument to aid PHAs' digitalization processeses to ensure that their employees are technically and organizationally able to deliver value to citizens, even in times of crisis. The PHAMM makes a significant practical contribution, because it can be used at the national level to fund and coordinate digitalization efforts and at the federal level to assess and increase PHAs' digital maturity. As a coordination tool, it allows for sharing experiences along the digitalization process. Our contribution to MM development shows how one can develop an MM by supporting decentralized institutions within a negotiation approach required for consensus-building. We consider the PHAMM to have a wide range of practical applications and substantial research potential to be exploited.

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