

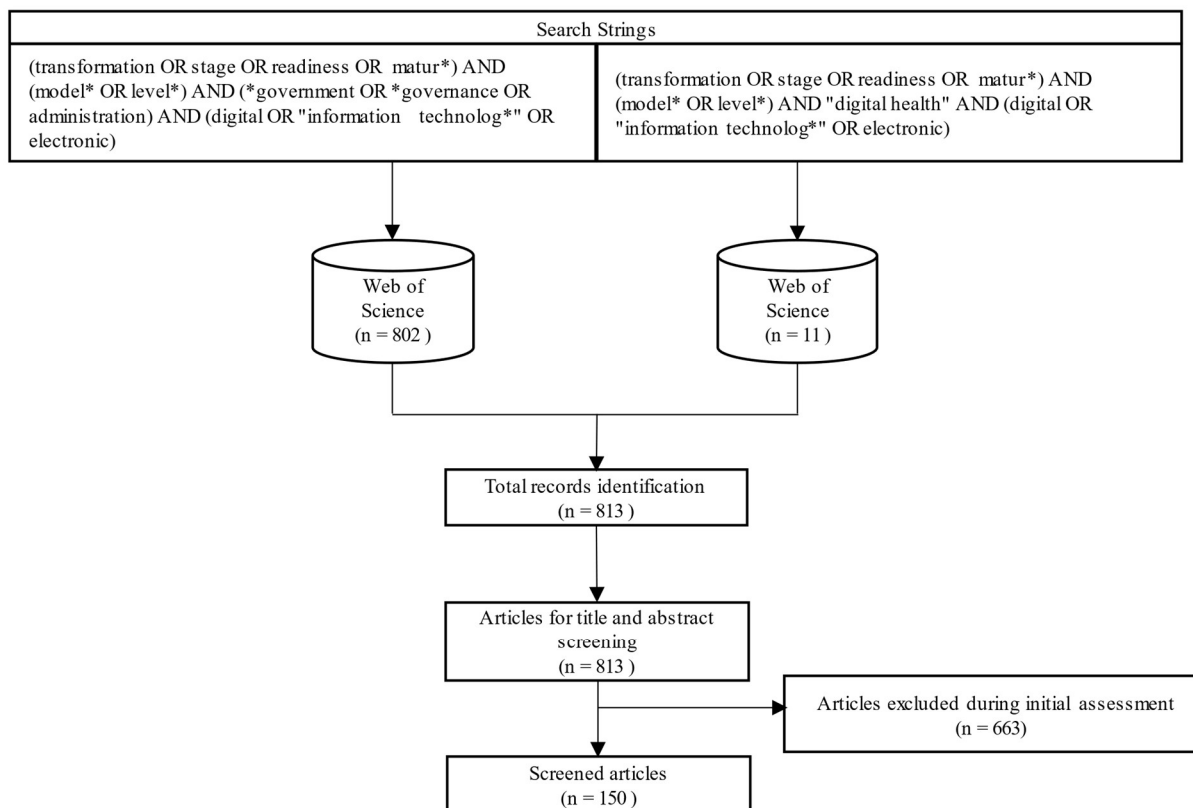
A Maturity Model for Assessing the Digitalization of Public Health Agencies – Development and Evaluation

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Appendix (available online via <http://link.springer.com>)

Appendix 1: The process of the literature review



Information: We developed a search strategy that included literature on digitalization of government agencies and healthcare organizations. To ensure the inclusion of all relevant studies, we tested numerous terms and their synonyms and discussed them among the research team (1). Finally, we decided on the shown two search strings.

We searched within the electronic database Web of Science because this database is one of the most influential databases and covers multidisciplinary research (2) and limited the search to topics (i.e., titles, abstracts, keywords) and specific categories (e.g., management, computer science information systems). For the first search string, 802 articles were identified without duplicates, while we could identify eleven articles for the second search string. After screening these articles, we identified 150 relevant articles. Information gathered in the literature study has revealed the lack of MMs for the problem at hand. Yet, we could use this information to inform the MM development, e.g., by using prior research to define a set of predefined dimensions, including IT-Strategy, Citizen Focus, Employees, IT Security, Interoperability, Processes as well as Hardware, and Software.

References:

- 1) Brocke, J. V., Simons, A., Niehaves, B., Niehaves, B., Reimer, K., Plattfaut, R., & Cleven, A. (2009). *Reconstructing the giant: On the importance of rigour in documenting the literature search process*.
- 2) Chadegani, A. A., Salehi, H., Yunus, M. M., Farhadi, H., Fooladi, M., Farhadi, M., & Ebrahim, N. A. (2013). *A comparison between two main academic literature collections: Web of Science and Scopus databases* arXiv preprint arXiv:1305.0377.

Appendix 2: Iterative process for (further) developing the interview guideline and changing the analysis codes based on an example (a) as well as the type of institutions included in the interview rounds 1-4 (b)

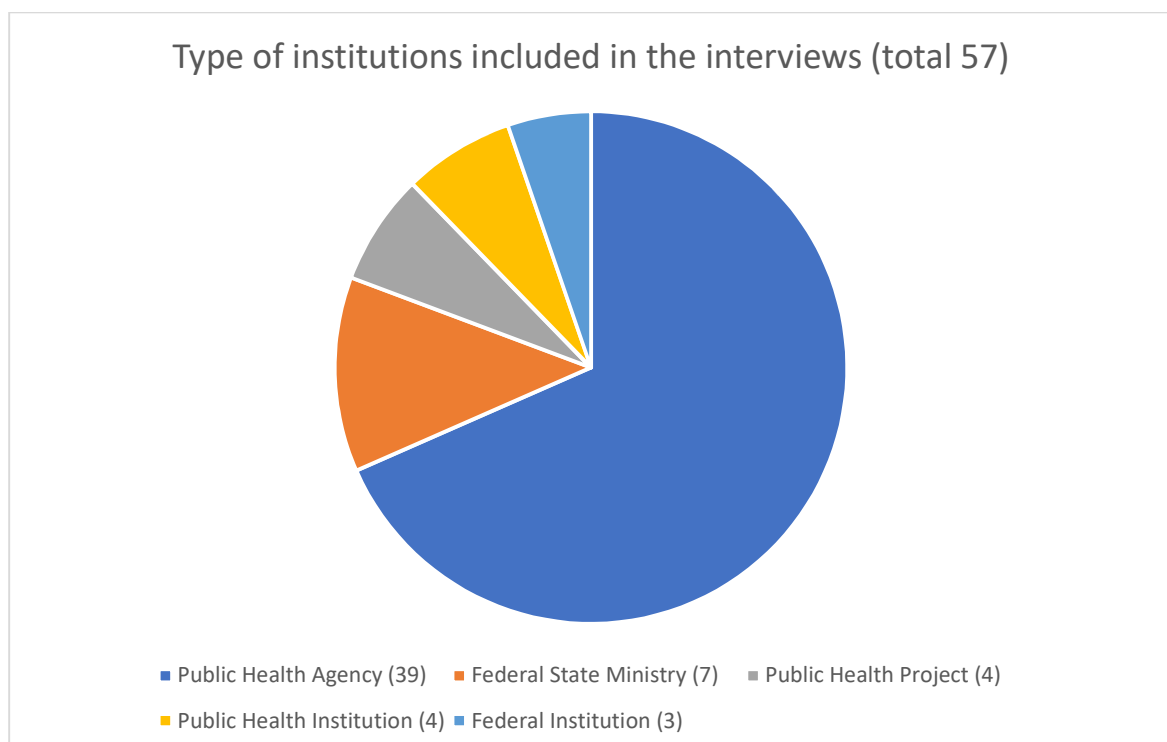
a) Iterative process for (further) developing the interview guideline and changing the analysis codes based on an example

In the following, we demonstrate how we derived the interview guideline and adapted the codes throughout the interviews using the example requirements and documentation within the dimension *software, data, and interoperability*. We were informed by the literature study that employee participation in defining new software functions and defining a prioritization process of the resulting functions contribute to advancing requirement definition (Tom-Aba *et al.*, 2020). We included both issues in the interview guide. In interview round one, these issues were supported by the interviewees. In interview round two, an interviewee suggested treating these two issues as separate practices, which led to formulating the two following practices:

- 1) *Employees are participating in defining new software functions, and*
- 2) *The definition of a prioritization process of software functions is fostered.*

Showing these practices within the PHAMM 0.8 in interview round three led us to change the practice related to employee participation. One interviewee argued that “employer participation is not a goal per sé.” Instead, employer participation points to the “need to continually improve a dialogue between employees and software developers” that allows for “defining functional and non-functional requirements that meet the employee's expectations and needs.” In the upcoming interviews, we discussed the original practice and the suggestion from the interviewer. As most interviewees preferred the suggestions, we had enough evidence to adapt the practice for PHAMM 0.9. We used interview round 4 to evaluate PHAMM 0.9 and its practices. As a result of this series, we rendered the two practices more precise using a more active style.

b) Type of institutions included in interview rounds 1-4



Appendix 3: Details on the survey

We started the evaluation with a survey to investigate usability, completeness, and appropriate step width using a five-point Likert scale. Details on the survey design can be found below in the questionnaire. Please note that we translated the questionnaire from German into English.

Example of the Online Questionnaire

Completeness of dimensions

A total of eight dimensions with one to five subdimensions are addressed in the PHAMM. In the subdimensions, criteria are recorded along five different maturity levels (see figure below). The PHAMM aims to capture the digitalization of PHAs as broadly as possible. We would like to know whether the dimensions of the maturity model are complete and accordingly reflect all the important points that play a role in digitalization.

Dimension	Employees	The employees dimension includes awareness, participation and training of employees.			Quick guide: For each criteria, select in the drop-down field whether the criteria has already been achieved ("Applies"), is not yet achieved ("Does not apply") or is being implemented ("In implementation").		
Selection		Level 0 Dimensional level not reached	Level 1 Dimensional level not reached	Level 2 Dimensional level not reached	Level 3 Dimensional level not reached	Level 4 Dimensional level not reached	Level 5 Dimensional level not reached
Subdimension	Awareness	Does not apply	Does not apply	Does not apply	Does not apply	Does not apply	Does not apply
Criteria		Does not apply	Does not apply	Does not apply	Does not apply	Does not apply	Does not apply
	Participation	Does not apply	Does not apply	Does not apply	Does not apply	Does not apply	Does not apply

Please rate the following statements:

I consider the dimensions of the maturity model mentioned below to be complete:

absolutely

not at all

Digitalization Strategy	☐	☐	☐	☐	☐
Employees	☐	☐	☐	☐	☐
Process Digitalization	☐	☐	☐	☐	☐
IT Security	☐	☐	☐	☐	☐
IT Provision	☐	☐	☐	☐	☐
Citizen Focus	☐	☐	☐	☐	☐
Cooperation	☐	☐	☐	☐	☐
Software, Data, Interoperability	☐	☐	☐	☐	☐

If in your opinion, one or more dimensions are not fully represented, we ask you to briefly explain this below.

Step size

The PHAMM includes five maturity levels. Criteria have been specified for each level in the subdimensions. Certain criteria must be met to move from one level to the next. The effort required to do this reflects the step width of two successive levels in the PHAMM.

The following figure shows an example of the step width for the dimension "Collaboration": If the criteria at level 0 are met, two additional criteria must be met to reach level 1. In this example, the step width reflects the effort required to fulfill these two criteria.

Collaboration within the health department	Level 0		Level 1	
	Dimensional level not reached		Dimensional level not reached	
	Applies	At least one initial IT-supported communication process across organizational units takes place (e.g., by e-mail).	Does not apply	There is at least planning for initial IT-based collaboration across initial organizational units of a health department where collaboration makes sense (e.g., psychosocial services and child and adolescent health services).
	Applies	The health department has its own health department-specific email address (e.g., GA@LandkreisX.de).	Does not apply	Employees use shared digital calendars for scheduling.
			Step width	

Please rate the following statements about the step width:

I rate the step width of the points in the dimensions of the maturity model listed below as applicable:

absolutely

not at all

Digitalization Strategy	☐	☐	☐	☐	☐
Employees	☐	☐	☐	☐	☐
Process Digitalization	☐	☐	☐	☐	☐
IT Security	☐	☐	☐	☐	☐
IT Provision	☐	☐	☐	☐	☐
Citizen Focus	☐	☐	☐	☐	☐
Cooperation	☐	☐	☐	☐	☐
Software, Data, Interoperability	☐	☐	☐	☐	☐

If in your opinion, the step width of some dimensions is not appropriate, we ask you to briefly explain this below.

Mechanism: When is a particular maturity level of (sub)dimension reached?

Currently, in the maturity model, a maturity level for (sub)dimension is considered to be fulfilled when at least 80% of the criteria contained therein have been met.

The following is an example of the dimension "Digitization strategy" / sub-dimension "Definition, communication and implementation" / level 2:

There is a total of five criteria in this maturity level. So, four out of the five criteria must be met to fulfill the maturity level.

	Level 0	Level 1	Level 2
	Dimensional level not reached	Dimensional level not reached	Dimensional level not reached
Definition, communication and implementation	Does not apply A digitization strategy exists for the health department or is at least in the planning stage.	Does not apply The requirements of the federal and state governments with regard to digitization are specified in the digitization strategy of the health department.	Does not apply The digitization strategy specifies the current state and the target state of the digital maturity of the health department. These states can be determined with the help of the maturity model.
	Does not apply Response option restricted from version 1.2: The current and target state of the health department's digital maturity is described or, at a minimum, the description is planned.	Does not apply Individual digitization measures in the health department have been defined.	Does not apply The digitization strategy is recorded in writing and is available to all employees.
		Does not apply Organizational units of the health department or specific tasks with digitization potential are known.	Does not apply The digitization strategy is evaluated at least once a year with regard to the achievement of set targets.
			Does not apply Individual organizational units derive short-, medium- and long term digitization measures from the digitization strategy.
			Does not apply Decisions relating to digitization are made in line with the digitization strategy.
	Level not reached	Level not reached	Level not reached

Do you have any comments regarding the mechanism, and if so, what are they?

Did you encounter any technical problems (e.g., a mechanism was not triggered correctly; classification for a particular criterion was not possible) when classifying into the maturity model?

Please provide us with substantive feedback on the technical issues you encountered in the text box below.

Usability of the current state of the PHAMM

Usability of the PHAMM

The maturity model was easy for me to understand.

absolutely

not at all

☐ ☐ ☐ ☐ ☐

The classification into the maturity model was possible within an appropriate time frame.

☐ ☐ ☐ ☐ ☐

The content of the PHAMM is transparent to me.

☐ ☐ ☐ ☐ ☐

I find the presentation of the PHAMM appealing.

☐ ☐ ☐ ☐ ☐

Please provide feedback on the usability of the PHAMM in the text box below:

Do you have further comments?
Please use the following text field for your comments:

In a previously held workshop, we invited all 375 PHAs to participate in the survey and received 34 responses. The results are summarized in the Table below. Usability was rated on average with 3.19 points. Questions about usability included the comprehensiveness of the PHAMM (3.19 points on average; agree absolutely =5; agree not at all=1), the time required for its application (2.96 points), the transparency of the content (3.22 points), and the presentation of the PHAMM (3.36 points). Completeness was rated on average with 3.87 points ranging from 3.68 to 4.03 for the individual dimensions. Furthermore, participants rated whether the step width for consecutive maturity levels was appropriate. This step width was rated with 3.57 points on average, ranging from 3.47 to 3.75 for the individual dimensions. We also included qualitative questions to improve the MM. These questions mainly focused on asking for an explanation, and further details in case participants rated quantitative items, such as usability, completeness, and appropriate step width, low. Furthermore, we asked for remarks and comments on the mechanism to determine the as-is and to-be digital maturity and for potential problems that participants encountered while using the PHAMM. Based on the qualitative results, we recruited interviewees with potentially helpful advice for the evaluation interviews.

Category	Dimension / Question	Mean	Variance	Mean (category)
Completeness	Digitalization Strategy	3.97	1.06	3.57
	Employees	3.97	0.93	
	Process Digitalization	3.84	0.97	
	IT Security	3.97	0.74	
	IT Provision	4.03	0.90	
	Citizen Focus	3.81	1.16	
	Cooperation	3.69	1.19	
	Software, Data, Interoperability	3.68	1.09	
Step width	Digitalization Strategy	3.75	0.90	3.87
	Employees	3.53	0.95	
	Process Digitalization	3.53	0.95	
	IT Security	3.60	1.08	
	IT Provision	3.68	1.09	
	Citizen Focus	3.47	0.95	
	Cooperation	3.53	1.02	
	Software, Data, Interoperability	3.50	1.02	
Usability	The PHAMM is easy for me to understand.	3.22	2.18	3.19
	The classification into the PHAMM was possible within an appropriate time frame.	2.96	1.86	
	The PHAMM content is transparent to me.	3.22	1.72	
	I find the presentation of the PHAMM appealing.	3.36	1.58	