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Interoperability Maturity Model: Orchestrator Tool for Platform Ecosystems

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Research Paper

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Abstract. The orchestration of platform ecosystems is becoming increasingly complex due to the growing number of players, complementary services and technological innovations. Interoperability is an important prerequisite for convincing customer journeys as well as functional and quality-assured data exchange and offers increasing potential for automation, especially with the help of machine learning or artificial intelligence. The interoperability maturity model developed in this study can be used as a conceptual framework to measure the interoperability of current and future platform ecosystem components and complements. The model, developed as an artifact of design science research, was evaluated using an iterative approach with orchestrators of health data platforms and their ecosystem. The results suggest that it can contribute to achieving and sustaining integrated value chains with multiple actors and diverse technologies, and can be used to assess the interoperability of care chains (e.g., care scenarios such as diabetes or cardiac insufficiency) and guide future interoperability considerations.

Keywords: maturity model, interoperability, design science research, health care platform ecosystem

1 Introduction

Several countries have implemented electronic health records (EHRs), which can serve as a central data hub to make current data silos accessible to exchange and reuse the data for health care, innovative health services, as well as research, using a platform approach (Kohli and Tan, 2016; Hermes et al., 2020; Reza et al., 2020). The goal is to make transactions more efficient and cost-effective, while improving the quality of care through the availability of information (e.g., Kohli and Tan, 2016; Hermes et al., 2020). Indeed, the challenge for platform owners and orchestrators in healthcare is to make data available throughout the patient journey and to the many stakeholders involved (Hermes et al., 2020). To achieve frictionless data flows, interoperability through transmission standards is essential. Both in the design and construction phase of the platform's architecture, as well as in the design of the ecosystem's outbound interfaces and standards for the integration of complementary services (Ghazawneh and

Henfridsson, 2013; Fürstenau et al., 2019; Gawer and Cusumano, 2014). *Interoperability* refers to "the ability of two or more systems or components to exchange information and to use the information that has been exchanged" (IEEE, 2002, p. 42). Interoperability issues can be considered at various levels, including technical, structural, syntactic, semantic, and pragmatic (e.g., Hodapp and Hanelt, 2022; Oemig and Snelick, 2016). As the level/degree of interoperability increases, the potential for automation also increases (Oemig and Snelick, 2016). This is particularly important for data-driven services such as health apps, as well as digital therapeutics (DTx; Fürstenau et al., 2023; Patel and Butte, 2020), a minimum degree of interoperability is necessary (Gregory et al., 2021), especially with self-learning algorithms such as artificial intelligence (AI; e.g., Lehne et al., 2019).

The primary purpose of *DTx* is to support and coordinate medical interventions through (different types of) digital applications which can be tailored to the individual conditions and needs of patients to support hybrid care scenarios (Fürstenau et al., 2023). Data are being created, and many data, such as from EHRs, are needed for data-driven services, such as AI. In order to assess whether the data quality meets the desired goals of the platform ecosystem, i.e., the functionality of the service can be guaranteed, determining the quality of the exchanged data is an important indicator for the integration of potential complementary services. Hodapp and Hanelt's (2022) call for research addresses the issue of making interoperability measurable. There are few maturity models (MM) in the literature for making interoperability measurable (e.g. MEASURE Evaluation, 2017). In the platform literature there are links to interoperability such as tools or frameworks in the area of platform construction (Baldwin and Woodard, 2009; Fürstenau et al., 2019), management of openness (Parker and van Alstyne, 2018), and boundary resources (Ghazawneh and Henfridsson, 2013) or MM for evaluating the platforms technology (Deale et al., 2019), but not with a focus on evaluating data flows and their quality (interoperability), which is very relevant for certain services, especially in health care (e.g. Lehne et al., 2019). This leads to the following research question:

How should a maturity model be designed to support orchestrators of platform ecosystems in evaluating the interoperability of service offerings?

To answer this question, the study followed a Design Science Research (DSR) to design a tool for platform ecosystem orchestrators to assess the nature of the data provided and exchanged to ensure the frictionless transfer of data and information, which also guarantees the quality of service of complementary service providers.

The subsequent sections of this study are organized as follows: Section 2 provides an overview of the concepts used. Section 3 explains the methodological approach and the data used to develop the MM, which is evaluated and demonstrated in Section 4. Finally, Section 5 discusses the results and their implications for future research.

2 Related Work

2.1 Digital platform ecosystems

Hein et al. (2019) define *digital platform ecosystem* as follows: “digital platform ecosystem comprises a platform owner that implements governance mechanisms to facilitate value creating mechanisms on a digital platform between the platform owner and an ecosystem of autonomous complements and consumers”. In highly regulated environments such as health care, especially in Germany, the architecture and core of the technical design as well as the infrastructure is largely specified (e.g., Stegemann and Gersch, 2021), and the role of platform providers is primarily to orchestrate transactions of care pathways via own and third-party services in the in the ecosystem, with less free governance than in other markets.

Cooperation with partners/complementors (e.g., manufacturers of DTx) should increase the added value of the platform and generate direct as well as indirect network effects (e.g., Eisenmann et al., 2008; Gregory et al., 2021). Depending on the strategy of both the platform and the partner, collaborations vary in the depth of integration into the platform ecosystem, from loosely coupled application offerings in the ecosystem to tightly coupled ones (Hein et al., 2019) that are deeply integrated into the platform (e.g., as a white-label service). Integration of complementary services from partners requires a certain openness of the platform (Parker et al., 2017; Eisenmann et al., 2008) and different requirements for interoperability depending on the level of integration as well as the technology used (Ondrus et al., 2015). The health care sector is inherently complex due to its numerous sectors and diverse stakeholders (Hanseth and Bygstad, 2015). As a result, healthcare platforms face challenges in achieving interoperability while orchestrating the complexities arising from disparate technological systems, varying levels of integration, and the provision of complementary services (e.g., Ozalp et al., 2022). This complexity is further amplified by the emergence of DTx (Patel and Butte, 2020) and the integration of health devices such as wearable devices, sensors, and vital signs trackers (Witte et al., 2020). The integration and interoperability of these technologies within healthcare platforms poses significant challenges, requiring careful coordination and standardization efforts to ensure seamless data exchange and effective functioning of the ecosystem.

2.2 Overview of maturity models for interoperability

MMs have been developed for more than five decades (Carvalho et al., 2019) and have been defined by Pöppelbuss and Röglinger (2011) as “[b]ased on the assumption of predictable patterns of evolution and change, maturity models usually include a sequence of levels (or stages) that together form an anticipated, desired, or logical path from an initial state to maturity”. MMs are commonly used to assess a current state, to derive and prioritize actions for improvement, and to monitor progress (Iversen et al., 1999). In research on informatics as well as information systems (IS), MMs are common tools to objectively evaluate complex technical conditions in order to derive decisions (e.g., Pereira and Serrano, 2020). MMs are used in various areas of application in research on IS (Becker et al., 2009), there are models for assessing business processes (Röglinger et al., 2012; Rosemann and Bruin, 2005; Scott, 2007), the digitalization of a health care system (Lee et al., 2022), digitalization at hospitals (HIMSS Analytics, 2017; DigitalRadar, 2023) and digitalization of public health agencies (Eymann et al., 2023). However, those models are usually designed for a particular use case or purpose. Depending on how applicable existing models are, they have to be adapted, or else a new model has to be created, at least according to the approach of Becker et al. (2009).

The literature contains several examples of MMs for interoperability. The first significant attempts to measure interoperability targeted levels of system interoperability—for example, C4ISR in 1988 (Campos et al., 2013)—and established a foundation on which later models were developed. Subsequent models, by contrast, focused more on a specific purpose or use case, including from the perspectives of enterprises (Campos et al., 2013, van Velsen et al., 2016), organizations (Clark and Jones, 1999), and government bodies (Gottschalk, 2009). Recent discussions about interoperability have shown that, along with a rather technical view, other dimensions are relevant when considering interoperability, including from the process perspective (e.g., Hodapp and Hanelt, 2022; European Commission, 2017), a regulatory or legal perspective (e.g., European Commission, 2017), and the perspective of the individual following an user-centric approach and the outcomes—for instance, for customer journeys, value in use, and learning and adaptation loops of service systems and/or data flows (e.g., Gohar et al., 2021; Sayeed et al., 2020). With the considerations afforded by an MM for interoperability, potential participants can use the model for orientation and to realize collaboration (Campos et al., 2013).

3 Method

3.1 Research design

Following Design Science Research (DSR) as an overarching research paradigm (e.g., Hevner et al., 2004; March and Smith, 1995; Nunamaker et al., 1990), the MM for interoperability was developed to answer the research question. The MM developed can be understood as an IT artifact which solves the problem of making the orchestrator's interoperability criterion measurable and assessable (e.g., for selecting complements to their platform ecosystem). The research design, shown in Figure 1, is inspired by Berger et al. (2020) and follows the DSR approach according to Hevner et al. (2004). The core development of the artifact is adapted from Becker et al.'s (2009) eight steps for designing an MM and complemented by additional iterative and structured evaluation (Eval) steps by Sonnenberg and vom Brocke (2012), all to meet the criteria for quality and rigor in IT artifacts. Step 1 of Becker et al.'s (2009) MM design approach includes understanding and defining the problem, the requirements and field observations are part of the *Problem Space* (see Section 3.2). In Step 2, knowledge of existing MMs for interoperability and relevant dimensions characterizing interoperability in the literature are examined in the *Solution & Knowledge Space* (see

Section 3.3). In Step 3, the design strategy is represented according to the DSR approach in this section (see Section 3.1). The iteratively developed of the MM is defined in Step 4 and *ex ante* evaluated in Step 5 (see Section 3.4). The demonstration and *ex post* evaluation occur in Steps 6 and 7 (see Section 4), while Step 8 entails publishing the approach, which claims to be a generalized approach and template for assessing interoperability for a specific use case or scenario according to individual weighted scores, as in follow-up publications (see outlook in Section 5).

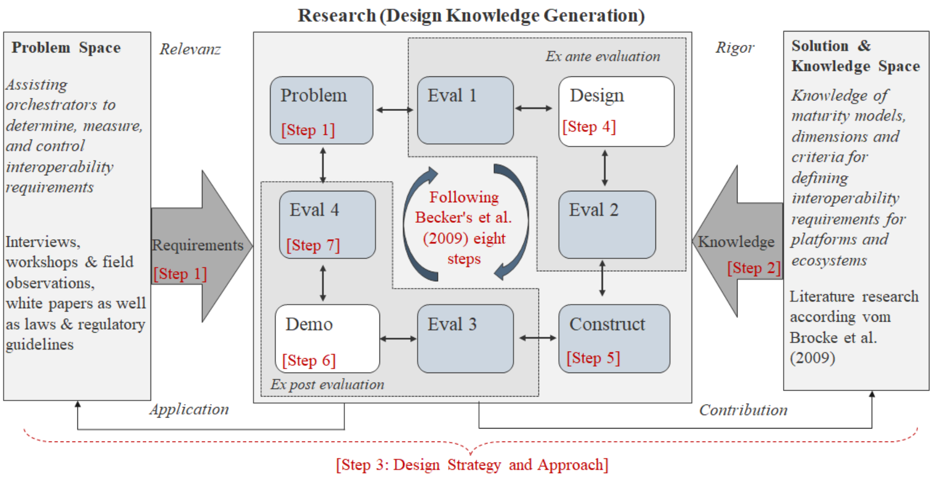

Figure 1. Research design, adapted from Hevner et al. (2004) and Sonnenberg and vom Brocke (2012) with embedded steps of the procedure model for MM according to Becker et al. (2009)

3.2 Problem space

The empirical data for the study was collected from 2021 to 2023 and included the documented field notes and results of a series of six workshops funded by the German Federal Ministry of Health from November 2021 to April 2022 and two additional workshops in December 2022 and February 2023. A total of 23 semi-structured interviews were conducted (Miles et al., 2014) in the development and evaluation process of the artifact, 12 interviews with platform ecosystem orchestrators from five health insurance companies (HICs; i.e., which includes approximately 40% of all insured people in Germany), four digital health experts, two of whom focus on interoperability, two interviews with patient representatives, three interviews with DTx manufacturers, and two interviews with digital health regulators in Germany. The field notes and interview transcripts were qualitatively analyzed (Miles et al., 2014) and partially coded within a software to handle the requirements and feedbacks in the evaluation phases of the artifact development, details are presented in the Section 3.4.

The MM was developed for platform ecosystem orchestrators of statutory HICs in Germany. Statutory HICs in Germany are required to provide each insured person an EHR that can be accessed by physicians and therapists. The insurant can access the EHR through an app provided by the HICs. In addition to the EHR functionality, most insurers offer a complementary set of services to differentiate themselves from the competition. In 2023, the EHR is projected to have a small number of users (BMG, 2023); however, insurers are aware that the number of users can be increased, especially through value-added and complementary innovative digital services in the platform ecosystem. In general, the EHR already contains data that can be used for additional services: “It is fundamentally important to make the data usable for other applications and services” (responsible platform ecosystem orchestrator of HIC A; this and the following quotes were translated from German). HICs want to be trusted digital healthcare providers and orchestrate the necessary services to achieve customer perception of attractive service offerings for healthy people (e.g., research and prevention), especially in the process from disease to treatment. They also seek to do so in an efficient way and thus achieve individual control over the resulting costs per insurant. Both aspirations require the orchestration of DTx (Fürstenau et al., 2023) and digital services along the patient journey. “Moving away from a payer's view to being a guide to help patients navigate their way” (responsible platform ecosystem orchestrator of HIC B). However, there is still a high demand for service integration, which users consider to be commonplace: “Patients have demands for a digital health insurance service offering that’s like Amazon” (responsible platform ecosystem orchestrator of HIC B). To demonstrate the development and evaluation of the artifact, two indication areas and their Disease Management Programs (DMP) were considered: cardiac insufficiency and diabetes. For both indications, different applications and devices (e.g., sensors, wearable devices, and closed-loop injection pumps) are available on the market. The scenarios and patient pathways are examined in the context of the two DMPs, so that the artifact can better provide objective help in selecting partners and complements for evaluating solutions from an interoperability perspective.

3.3 Solution space and knowledge space

To gain an overview of existing models for interoperability, a systematic literature review was conducted following vom Brocke et al. (2009) to expand the knowledge space for the design process. The review sought an overview of the dimensions of interoperability for the artifact. Because there are few models of interoperability and because some of the MMs mentioned above are not state-of-the-art due to subsequent technological progress and/or do not emphasize platforms. Therefore, the review also looked for frameworks for addressing and characterizing dimensions of interoperability in general. The results were found using the following search string:

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"interoperab*" NEAR/2 (framework OR maturit* OR model) in Title
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The search was executed in three databases: EBSCOhost (i.e., in Academic Search Ultimate, Business Source Premier, and EconLit), Web of Science, and AISEL (in all repositories in the database). The search query returned 263 results in EBSCOhost, 186 in Web of Science, and 87 in AISEL, for a total of 536 hits. The results were iteratively filtered in the search process. First, the articles had to be in English or German, peer-reviewed, and not duplicated in the result set, which left 349 articles. Second, the articles needed to relate to a conceptualization of interoperability, which left 59 articles.

Third, the articles had to provide a generalized conceptualization of interoperability in order to derive criteria and dimensions for the model, leaving 16 articles. Fourth, using a forward and backward search, five additional relevant articles were found for the result set, bringing the total to 21 articles. In the analysis phase described by vom Brocke et al. (2009), the articles were examined more closely and classified. Four of the 21 articles had very strong relations to the same models or frameworks and were therefore eliminated due to strong redundancy. Based on the 17 remaining articles, 164 dimensions and views were identified, all redundancies were eliminated, and the remaining 89 dimensions were iteratively condensed into seven dimensions that all characterize interoperability. The dimensions were part of the artifact and its design process and were therefore iteratively condensed and validated in the evaluation cycles. The condensed dimension in relation to the corresponding articles is shown in Table 1, while the definitions of the dimensions are described in Section 4.1.

Table 1. Concept matrix of the condensed dimensions from the literature

Author(s) and kind of contribution (i.e., F or M) / **Dimensions**		**Individual**	**Care Process**	**Legal & Governance**	**Organizational & Business**	**Application & Service**	**Data & Information**	**Technical**
Berre et al., (2007) [ATHENA]	F		X		X	X	X	
Bastiaansen et al., (2020)	F	X		X	X		X	X
Benson and Grieve, (2016)	F	X		x	X		X	X
Campos et al., (2013)	M	x	X				X	x
Clark and Jones, (1999)	M		X		X	x		X
eHealth Network, (2015) [EIF]	F		X	X	X	X	X	X
European Commission, (2017) [REIF]	F	X	X	X	X	x	X	X
Guédria et al., (2015) [NEHTA]	M		X	x	X	X	X	X
Gottschalk, (2009)	M	x	X		X		X	X
Hodapp and Hanelt, (2022)	F	X		X	X	X	X	X
Legner and Wende, (2006)	F		X		X	x	X	X
MEASURE Evaluation, (2017)	M	X		x	X		X	X
Ndlovu et al., (2021)	F	x					x	X
Panetto, (2007)	M				X		X	X
Peristeras et al., (2009)	F		X				X	X
Sullivan, (2017) [GCIMM]	M	X	X	X	X		X	X
van Velsen et al., (2016)	M		X					X

Legend: X= fully applicable, x= partly applicable, F= Interoperability Framework, M= Interoperability Maturity Model

3.4 Design and evaluation process

Figure 1 shows the iteratively development approach of the MM, starting with the first phase *problem and requirements analysis* **(Problem & Eval 1**). The implications were gathered from three of the funded workshops conducted in 2021-2022 on the topic of interoperability of DTx with, among others, digital health experts, DTx manufacturers, physicians and patient representatives. In addition, the workshop findings were refined through interviews with suitable workshop participants; two patient representatives, two manufacturers of DTx, two orchestrators of the digital platform ecosystem of HIC, two representatives of standardization organizations and regulators to study the problem space. Inspired by the implications and collected requirements of the first phase, a first prototype of the artifact was designed in the second phase of the *interim evaluation* **(Design & Eval 2)** and evaluated through four interviews: two with responsible orchestrators of the digital ecosystem of public health insurers, one with a representative of the German authority for digital health regulation, and one with a manufacturer of DTx. As a result of the feedback, the artifact was significantly revised e.g., by expanding the dimensions of interoperability from the original five to seven, as described in Sections 3.3 and 4.1. Feedback on this topic included "Legal requirements also need to be considered" (platform orchestrator of HIC C) and "Data use and reuse can help in contracting with health insurance companies" (representative of digital health regulation in Germany). In the third phase, *refactoring* **(Construct & Eval 3)**, additional requirements for the revision were collected in interviews with five orchestrators of the digital platform ecosystem of HIC conducted in 2021-2022 and two digital health experts, as well as field notes, implications of the workshop series, and recent developments in health care digitization. At the end of the revision process, the model approach was presented for discussion in two workshops with IS researchers and health experts, with the result of simplifying the model and clarifying the definitions of the dimensions and the five levels (see Section 4.1 and 4.2). In the final evaluation phase **(Demo & Eval 4),** the MM was evaluated based on two scenarios (i.e., diabetes and cardiac insufficiency; see Section 4.3) using iterative steps after each interview conducted from January to March 2023, with four responsible orchestrators of the digital platform ecosystem of three HIC and two health experts in interoperability.

4 Maturity model of interoperability

4.1 Dimensions of the interoperability framework

Table 2 shows the elaborated and evaluated dimensions with their related subdimensions from the literature based on the concept matrix (see Table 1), descriptions, and guiding questions. First, the *Technical* dimension captures the ability to transfer data via communication formats or protocols, within an infrastructure or with another system (e.g., Benson and Grieve, 2016). The *Data & Information* dimension, by contrast, captures the nature of the exchanged data in terms of syntactic structure (e.g., per standards such as HL7 and FHIR) as well as semantic nature in view of reference or information models and coding based on terminologies such as LOINC or

SNOMED CT. Next, the *Application & Service* dimension considers interoperability in terms of whether and how the exchanged data can be processed in order to guarantee functionality, which requires latencies, availability, and findability (e.g., European Commission 2017). Meanwhile, the *Organizational & Business* dimension describes to what extent necessary data are available to perform a service or action based on the data (e.g., according to contracts or process instructions) and includes pragmatic interoperability standards (e.g., medical guidelines), which partly overlaps with the process view according to Gottschalk (2009). The *Legal & Governance* dimension captures general conditions and requirements for interoperability that are recommended or mandatory specified by standard development organizations for instance (Sullivan, 2017).

Table 2. Guiding questions and definition of the dimensions of interoperability

Dimension	Subdimension	Definition	Core question
Individual	Data sovereignty, digital empowerment, user-centricity	Enables sovereign handling of shared and exchanged data from an individual's perspective	Can users exchange and share data in a self-determined manner?
Care Process	Patient's journey, data accessibility, process	Interoperability considerations from a patient journey perspective, sections of a care scenario and stakeholders, as well as different applications	Will the assessment be conducted from a care scenario or process perspective?
Legal & Regulatory	Laws, regulations	Aspects of legal as well as regulatory compliance of interoperability	Are regulatory and legal requirements considered and adhered to?
Organizational & Business	Policies, guidelines, pragmatic and procedural standards, contracts, agreements	Organizationally and inter-organizationally compliant actions based on the exchanged data/information according to instructions	Does the data exchanged support and comply with the relevant agreements, contracts, and guidelines?
Application & Service	Software, latencies data representation, availability, findability	Exchange of data and/or information without loss and its processing and comprehension in a timely manner	Are the required data and information findable, accessible, and reliable?
Data & Information	Reusability, metadata knowledge, sematic & syntactic standards, data or information models or profiles	Nature of the data and/or information in terms of syntactic and semantic standards and data and/or information models	How are the data structured and coded?
Technical	Architecture, infrastructure, network protocols	Aspects of the required infrastructure as well as system architecture for data exchange	Is the compatibility with the necessary infrastructure given?

The dimension of the *Care Process* considers data exchange as a process—for instance, as a care path along which actors participate beginning with data exchange and can aggregate the data in a generative way. However, alternative views understand interoperability and the correctness of data entry and coding from a human perspective (e.g., Campos et al., 2013), an aspect not considered in this MM. Early interoperability MMs indeed examined interoperability from the perspective of single point-to-point data exchange. Last, the *Individual* dimension considers self-determination of the exchange of data as well as the flexibility or even possibility of data transmission (e.g., European Commission, 2017; Bastiaansen et al., 2020).

4.2 Level of interoperability maturity

The literature contains many examples of a gradation of maturity in five levels that date back to early models in the field of interoperability (e.g., Clark and Jones, 1999; Gottschalk, 2009). From the literature and empirical data collected in this study, including field observations and interviews, the five levels shown in Figure 2, were derived, developed, and evaluated as described in Section 3.2 and 3.4. The gradation of interoperability in the area of platform solutions starts at *Level 1* and is characterized by a fragmented and unstructured data exchange. *Level 2* represents the typical industry as well as regulatory and legal minimum requirements for interoperability, which are exceeded in *Level 3*, were the data offer a higher potential for automation due to the semantic nature. *Level 4* represents international interoperability with a high degree of automation, “the goal should be to operate across national borders“ (platform orchestrator of HIC D), while *Level 5* stands for the possibility of flexible cross-domain data exchange. According to one interviewee, “Levels 1–3 are currently the reality; Levels 4–5 are the future” (digital health and interoperability expert I). The five levels provide gradations of a current state and offer an outlook for future development.

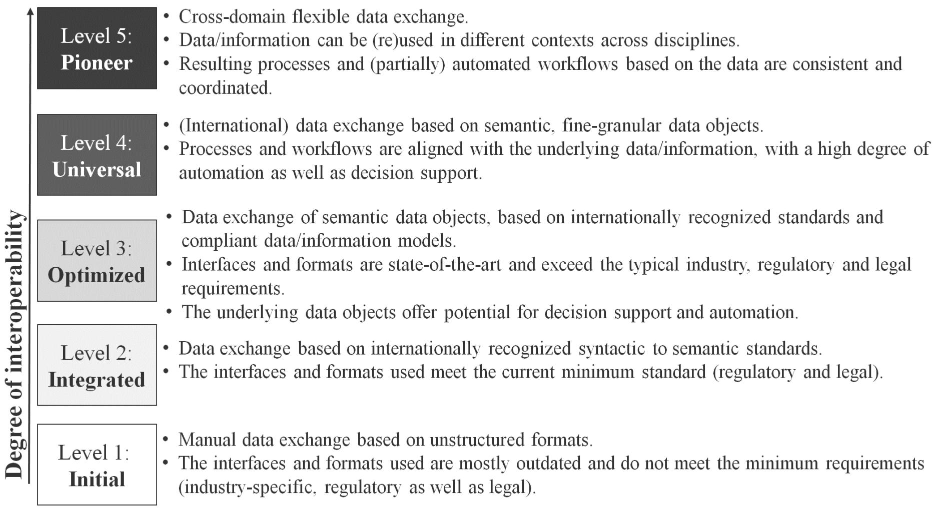

Figure 2. Level of interoperability maturity

4.3 Demonstration and adaption of the artifact

The maturity model can be demonstrated from the perspective of an HIC that orchestrates the service offerings of its platform ecosystem in order to support care paths digitally. The assessment always depends on the use case and may require adjustments to the model—for instance, adapting the dimensions to the five levels and weighting in scoring, “Depending on the core user and use-case, dimensions are weighted differently e.g., that data is made usable in the care process“ (platform orchestrator of HIC E). In the following, the use of the MM is outlined with an example in the diabetes DMP. In the first step, the choice of the use case for the platform’s vision is made. The health insurer wants to implement a frictionless care pathway, with a high degree of integrated care processes between the players involved in the DMP. In the second step, the target interoperability level for the use case is defined (see Figure 2), and the necessary properties related to the use case are adapted in the model (e.g., by adding dimensions and specific questions for the evaluation). In step 3, potential applications are evaluated using the adapted MM (e.g., use-case specific the dimensions and levels in a matrix). For that purpose, an a DTx, consisting of an App with the associated devices and sensors (e.g., diabetes meters) is evaluated. In the following, the assessment along the 7 dimensions and the classification in the 5 levels are described, with a short justification for the classification in the respective level and what was missing for the next level. In the *Individual* dimension, the application reaches Level 3 out of the 5 levels, because the data are encapsulated in the application and access to the data is restricted via the portal. The transfer of data from and to other systems (e.g., other manufacturer) is not supported. Considering the *Care Process* dimension, Level 3 is reached, because the data along the care path are fragmented, and not all health data can be included in the digital path for the DMP. Considering the *Legal & Governance* dimension, the DTx is a certified medical product in Germany that complies with all regulations and laws (e.g., data protection), meaning that it reaches Level 4. As for the *Organizational & Business* dimension, the product is based on medical guidelines and is a digital component of DMPs and thus achieves Level 3 on that count (automated processes and cross-domain scenarios are not yet considered). Regarding the *Application & Service* dimension, the patient can give the physician access to the data but not for the software of the physician’s practice that would allow its use with existing data. As such, the product reaches Level 2 in that dimension. Regarding the *Data & Information* dimension, the data can be exported and structured to be machine-readable (e.g., using HL7 FHIR R4) as well as unstructured for human reading as a PDF, but only manually and cannot be processed by third-party applications. Thus, it also reaches Level 2 in that dimension. On the T*echnical* dimension, the application works only with components, devices, and sensors from the same manufacturer, which keeps it at Level 1 in that regard. On average across all dimensions (without separate weighting) the diabetes application achieved an interoperability score (Level) of 2.6 and did not yet reach the estimated interoperability Level of 3 for the insurance platform ecosystem. Suggestions for improvement are therefore to better integrate the Technical as well as the *Data & Information* dimensions in the process—for instance, by connecting to the EHR as a central data hub.

5 Discussion

The interoperability MM, with its seven dimensions and five levels of interoperability maturity, was created based on a systematic literature review and empirical field observations in discussions about digital health and in several workshops and interviews following an iterative evaluation approach using two indication areas, one of which (i.e., diabetes) was outlined for an application (see Section 4.3). In this study, two use cases, both consisting of an application and a medical device (sensor), were evaluated to assess the data flow from the sensor along a typical patient journey. However, the MM provide a framework that needs to be adapted depending on the use case, including the weighting of the dimensions as well as the transfer of the five levels and the meaning of the dimensions based on the use case.

The **practical implications** of the study relate to addressing the challenges discussed for orchestrators, such as the complexity of orchestrating integrated and interoperable care scenarios. To ensure data flow in the care scenarios, the Interoperability MM can help define requirements and evaluate both proprietary and potential third-party platform ecosystem components (e.g., data, sensors, and devices).

The **research implications** of the study: firstly, the literature does not yet contain an interoperability MM for platforms. This study contributes to closing that gap by discussing interoperability challenges from a platform perspective and evaluating them in the development of the interoperability MM. The MM can be part of a toolkit in the platform development process (e.g., Fürstenau et al., 2019), for example, to evaluate the component from an interoperability perspective along care chains i.e., the patient journey. Second, another key implication is that in an increasingly connected, data-driven world, interoperability is an important criterion that will be assessed in multiple dimensions to realize integrated and interoperable service offerings along care chains—for example, using orchestration components and complements in care scenarios for insurants. Thirdly, beyond that, the interoperability MM responds to Hodapp and Hanelt's (2022) call for research geared toward making interoperability measurable.

As for the study's **limitations**, aside from general doubts in the literature regarding the broad generalization of artifacts (e.g., Beck et al., 2013), the interoperability MM revealed that a suitable compromise has to be found between general validity and the necessary concretization for specific use cases. The MM seems to address important points of interoperability with the five levels and seven dimensions through core questions. However, use case specific adaptations may still be necessary.

Outlook. Levels 4 and 5 of the MM imply scenarios for potential developments of interoperability and thus offer opportunities for future research on the orchestration of platform ecosystems—for example, increasing the merging of data sources internationally, including the European Commission's (2023) "My Health at EU", as well as across domains scenarios, including into smart health and smart living. Those scenarios become conceivable in the context of data spaces (e.g., Beverungen et al., 2022) as well as legislative initiatives (e.g., European health data space). The scope of orchestration becomes much more extensive due to the multiple actors in a data space and offers potential for use as part of an orchestrator's tool box.

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