Development and Validation of a Useful Taxonomy of Patient Portals Based on Characteristics of Patient Engagement

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Abstract

Objective   Taxonomies are classification systems used to reduce complexity and better understand a domain. The present research aims to develop a useful taxonomy for health information managers to classify and compare patient portals based on characteristics appropriate to promote patient engagement. As a result, the taxonomy should contribute to understanding the differences and similarities of the portals. Further, the taxonomy shall support health information managers to more easily define which general type and functionalities of patient portals they need and to select the most suitable solution offered on the market.

Methods   We followed the formal taxonomy-building method proposed by Nickerson et al. Based on a literature review, we created a preliminary taxonomy following the conceptional approach of the model. We then evaluated each taxa's appropriateness by analyzing and classifying 17 patient portals offered by software vendors and 11 patient portals offered by health care providers. After each iteration, we examined the achievement of the determined objective and subjective ending conditions.

Results   After two conceptional approaches to create our taxonomy, and two empirical approaches to evaluate it, the final taxonomy consists of 20 dimensions and 49 characteristics. To make the taxonomy easy to comprehend, we assigned to the dimensions seven aspects related to patient engagement. These aspects are (1) portal design, (2) management, (3) communication, (4) instruction, (5) self-management, (6) self-determination, and (7) data management. The taxonomy is considered finished and useful after all ending conditions that defined beforehand have been fulfilled. We demonstrated that the taxonomy serves to understand the differences and similarities by comparing patient portals. We call our taxonomy "Taxonomy of Patient Portals based on Characteristics of Patient Engagement (TOPCOP)."

Conclusion   We developed the first useful taxonomy for health information managers to classify and compare patient portals. The taxonomy is based on characteristics promoting patient engagement. With 20 dimensions and 49 characteristics, our taxonomy is particularly suitable to discriminate among patient portals and can easily

be applied to compare portals. The TOPCOP taxonomy enables health information managers to better understand the differences and similarities of patient portals. Further, the taxonomy may help them to define the type and general functionalities needed. But it also supports them in searching and comparing patient portals offered on the market to select the most suitable solution.

Introduction

The advent of the internet and the rapid digitization of all areas of life have also lead to significant changes in the health care field worldwide.[1] The emergence of patient portals in the early 2000s [2] was a logical consequence of the introduction of electronic health records (EHR) in the 1990s.[3] A patient portal is an internet-based application allowing patients to have autonomous access to their EHR anywhere at any time.[4] Besides EHR access, a patient portal may also offer additional functionalities[5] such as access to test and laboratory result, viewing visit notes, requesting medication refills, appointment scheduling, or secure messaging with the health provider.[5–8]

Patient portals are considered a health information technology that promotes patient engagement by providing tools to become active participants in one's own care.[9–11] Patient engagement has received considerable attention in recent years,[10] and patient portals may contribute to engaging the patients actively in their care by granting them access to their health data and providing additional functionalities.[7,12–14]

To date, we find a very heterogeneous landscape and a broad diversity of patient portals[15] regarding their intended deployment and functionalities.[8,16] Patient portals can be projected for specific care sectors, for example, primary or secondary care based on each care sector's different needs. They may also follow an approach not specific for a sector. Further, patient portals may also focus on particular diseases and offer disease-specific functionalities to enhance the treatment of specific patient groups, for example, patients with asthma,[17] renal conditions,[16] or diabetes.[18] These different application areas and scopes of patient portals are mirrored in the diversity of functionalities that patient portals may offer, for example, concerning the method of communication between patients and physicians, the possibility to report and grant access to patient-generated health data in the portal, or the possibilities of patients to manage access to their health data. These different application areas and scopes of portals and the resulting large variability in offered functionality highlight the complexity of patient portals' domain and the challenge to match the specific requirements of the clinical setting to patient portals available on the market. This was confirmed by explorative interviews that we performed from 2018 to 2020 with software vendors of patient portals and with health information managers in Germany, Switzerland, and Austria. In these interviews, we found that many health information managers still feel that they have too little knowledge of patient portals. They thus have difficulties understanding the various application areas and scopes of portals, defining their own general requirements, and selecting the best patient portal for their specific context or problem. Health information managers are involved in selecting, introducing, and managing patient portals for their health institution. A patient portal taxonomy would help them to more easily define which general type and functionalities of patient portal they need and to search and compare patient portals offered on the market to select the best solution. Classifying patient portals with a taxonomy may show them more clearly the similarities and differences of patient portals and support them in their selection decision. The need for a patient portal taxonomy was also stressed in a recently published Cochrane Review on the impact of patient portals.[19]

At present, there exist just a limited number of publications related to patient portal taxonomies. Ammenwerth et al[4] developed a taxonomy that aims to distinguish patient portals in a systematic review dealing with their effect on patient empowerment and health-related outcomes. Roehrs et al[1] developed a taxonomy that aims to identify open questions related to personal health record (PHR) data types, features, and architecture types. A PHR or personal health record provides patients with web-based access to their health data that is under the control of the patient,[1] while an EHR typically is under the control of the provider.[5,9,14] Scheplitz et al[20] created a framework for patient portal functionalities to record all possible functions to identify specification gaps related to software development. Walker et al developed a framework to evaluate how well health information technology can support patient engagement by applying five engagement scoring levels.[10]

These attempts only provide parts of a potential patient portal taxonomy and are developed for different users and purposes. Since the user determines the intended purpose of a taxonomy and the purpose guides the development by focusing on a specific phenomenon of interest,[21,22] different users or purposes may lead to different taxonomies.[23] Further, a useful taxonomy must yield utility for a specific problem domain.[24] To sum up, the found taxonomies are not suitable to yield utility for classifying and comparing patient portals based on characteristics appropriate to promote patient engagement and to understand the differences and similarities.

A taxonomy is a classification system to classify similar objects of a domain into groups based on distinct characteristics and offers a set of decision rules.[23,25–27] Various classification structures have been used to construct taxonomies in various domains.[28,29] For our research, we follow Nickerson et al,[23] who define a taxonomy T as a set of n dimensions D_i ($i = 1, \ldots, n$), with each dimension consisting of k_i ($k_i \geq 2$) mutually exclusive and collectively exhaustive characteristics C_{ij} ($j = 1, \ldots, k_i$).

Objective

This research aims to develop a useful taxonomy for health information managers to classify and compare patient portals based on characteristics appropriate to promote patient engagement. As a result, the taxonomy should contribute to understanding the various application areas and scopes of portals. Further, it should help them to more easily define which type and general functionalities of patient portal they need. However, the taxonomy is not intended to serve as a standard framework for patient portal functional requirement specification. Classifying patient portals with a taxonomy may more clearly show the similarities and differences of patient portals to the health information managers and support them in their selection decision of portals offered on the market.

Methods

Taxonomies can be developed very informally and ad hoc, based on the specific knowledge in a given domain, or they can be constructed in a highly formal and standardized manner.[28] For our research, we adopted a more formal taxonomy-building method proposed by Nickerson et al.[23] This method is particularly suitable for our purpose as it specifies the necessary steps and integrates two optional, iterative development approaches to conceptionally build and empirically evaluate our taxonomy.[30] Further, the method defines ending conditions determining when our taxonomy is useful and when to end the iterative develop-ment cycles. We will now outline the two research cycles and the major iterations we conducted, the ending conditions we defined, and the definition of "usefulness" of the taxonomy. In ►Supplementary Appendix A (available in the online version), we describe the method in more detail.

First Research Cycle—Developing the Taxonomy
Following the method, we first defined the users and the intended use of the taxonomy. Second, we specified the meta-characteristic of the taxonomy, and third, we determined the ending conditions. Then we developed a preliminary taxonomy using two iterations, applying the conceptional-to-empirical approach in each. After each iteration, we checked if taxonomy

revision was needed and verified the fulfillment of all ending conditions. We now describe these steps in more detail:

Defining Users and Intended Use
The method by Nickerson et al requires a clear definition of the user and the intended use of the taxonomy.[23] Our taxonomy's projected users are health information managers. They are responsible for obtaining, monitoring, and securing the clinical databases and the EHRs to ensure that health care providers and patients can access patient health information when and where they need it.[31] Their intended use is to classify and compare patient portals based on the characteristics and functionalities of the portals that seem appropriate to support patient engagement. This allows the user to compare patient portals (e.g., during system selection) and better understand the differences and similarities.

Defining Meta-characteristic
The taxonomy's intended use is the central determinant for choosing the meta-characteristic, because all dimensions and characteristics must be a logical consequence of the meta-characteristic.[23,32] We thus defined the following meta-characteristic: portal characteristics useful to compare patient portals based on their ability to promote patient engagement.

Defining Ending Conditions
Since the method is iterative, we specified ending conditions, presented in ►Tables 1 and 2, to determine when to end the iterative development process and when the taxonomy is considered a "useful taxonomy." Our objective was not to create the best taxonomy, but a "useful taxonomy." Since there is no objective metric to determine the usefulness or quality of a taxonomy,[26] we adopted the subjective ending conditions (►Table 2) for a "useful taxonomy" as proposed by Nickerson et al.[23]

First Iteration of Taxonomy Development
In the first iteration, we created an initial taxonomy based on the patient portal taxonomy proposed by Ammenwerth et al.[4] We selected suitable dimensions applying the concep-tional-to-empirical approach. Based on the method by

Table 1 Fundamental and supplementary objective ending conditions for a useful patient portal taxonomy

Fundamental objective ending conditions	Description
• Collectively exhaustive	All patient portals of interest fall into one of the characteristics within a dimension
• Mutually exclusive	No patient portal falls into more than one characteristic within a dimension
Supplementary objective ending conditions	
• All patient portals of interest were examined. • At least one patient portal is classified under every characteristic of every dimension. • No new dimension or characteristic was added in the last iteration. • No dimension or characteristic was merged or split in the last iteration. • Every dimension is unique. • Every characteristic is unique within its dimension. • Each taxon is unique and is not repeated.	

Table 2 Subjective ending conditions for a useful patient portal taxonomy

Subjective ending conditions	Description
It should be concise	The taxonomy should not contain too many dimensions or characteristics in each dimension because a taxonomy with too many dimensions and many characteristics would be difficult to comprehend and to apply.
It should be robust	The taxonomy should provide enough dimensions and characteristics to be of interest. The dimensions and characteristics provide for sufficient discrimination among patient portals.
It should be comprehensive	The taxonomy should include all dimensions and characteristics to classify all patient portals of interest.
It should be extendible	The taxonomy should allow for additional dimensions and new categories within a dimension when new patient portals appear.
It should be explanatory	The dimensions and characteristics should explain the objects of interest sufficiently.

Nickerson et al, "conceptional-to-empirical" means to create characteristics and dimension by theoretical foundation.

Second Iteration of Taxonomy Development

The second iteration was based on a qualitative literature review, again applying the conceptional-to-empirical approach. From March 2020 to May 2020, we conducted electronic searches in the databases PubMed (Medline), Cochrane Library, IEEE Xplore, and ACM Digital Library. A preliminary search showed that researchers use different terms to refer to a patient portal. The diversity of terms used made it necessary to extend our search terms to multiple synonyms and acronyms for the search term "patient portal" (►Supplementary Appendix B; available in the online version). We combined in our search the primary search terms with each of the complementary search terms using the Boolean operators (►Supplementary Appendix C; available in the online version).

Our searches identified 40 relevant publications which we analyzed by applying the summarizing content analysis, an inductive analysis method was proposed by Mayring.[33–35] The meta-characteristic, mentioned above, guided the selection of the characteristics. We identified other characteristics adequate to distinguish among patient portals and created new dimensions. Further, we split dimensions from the first iteration to address the identified characteristics adequately. In ►Table 3, we present the results of the literature database search. In ►Supplementary Appendix D (available in the online ver-

sion), we present the inclusion criteria for publications, and in ►Supplementary Appendix E (available in the online version), a list of all publications included in our research and the derived characteristics.

Second Research Cycle—Evaluation of the Taxonomy

The result of the first research cycle is a preliminary taxonomy that describes the dimensions and characteristics of a patient portal. In the second research cycle, we now evaluated the appropriateness of each dimension and characteristic using two iterations and applying the empirical-to-conceptional approach. Based on the approach by Nickerson et al, "empirical-to-conceptional" means empirically evaluating the theoretically derived characteristics and dimensions through the use of real patient portals. Further, this approach also intends to create new characteristics and dimensions by classifying real patient portals. At the end of the second research cycle, we demonstrate how to use the final taxonomy to compare two patient portals.

Third Iteration of Taxonomy Development

We started the evaluation by analyzing product descriptions of patient portals offered by software companies and classified the portals with our preliminary taxonomy. From September 2020 to November 2020, we searched the DMEA (digital medical expertise and applications [trade show]) Virtual Market Place for software vendors offering patient portals. DMEA is Europe's most important trade show for digital health care, with 576 exhibitors in 2020.[36] We present the companies'

Table 3 Results of literature search and publications included in the research

Source	Search order	Results screened	Read title and abstract	Read in full text	Included in research
Researchers	1	3	3	3	3
PubMed	2	2,965	259	90	22
Cochrane	3	808	72	21	7
IEEE Xplore	4	552	43	16	4
ACM DL	5	1,276	68	18	4
Total		5,604	445	148	40

Abbreviations: ACM DL, Association for Computing Machinery Digital Library; IEEE Xplore, Institute of Electrical and Electronics Engineers Digital Library.

Table 4 Results of the search for companies and their inclusion in the research

Source	Companies analyzed	Companies that offer portals	Included
Researchers	4	4	4
DMEA	83	39	13
Total	87	43	17

Abbreviation: DMEA, digital medical expertise and applications (trade show).

inclusion criteria in ►**Supplementary Appendix F** (available in the online version).

We explored products and vendors, searching by category and keywords (►**Supplementary Appendix G**; available in the online version). First, we analyzed the product descriptions published in the Virtual Market Place, following-up on those companies that appear to offer a patient portal. Since the product descriptions published on most companies' web sites were not very clear, we contacted the companies by phone and e-mail to find out if they offer a patient portal. If affirmative, we inquired detailed product information by e-mail. In addition to the search on DEMA, we included in our research companies recommended by other companies or known by the researchers. In ►**Table 4**, we present the results of the search for companies and their inclusion in the research.

We analyzed the product descriptions of 17 patient portals applying Mayring's summarizing content analysis.[35] Based on the characteristics identified in the portals' product descriptions, we classified the included portals to verify the preliminary taxonomy. Further, we aimed to find other characteristics to create new dimensions and extend existing dimensions.

Fourth Iteration of Taxonomy Development

For the second evaluation step, we purposefully selected patient portals of health care providers and national health care organizations available online. We applied a convenience sampling strategy and analyzed nine portals that emerged during the literature review and two portals known by the researchers. In ►**Supplementary Appendix H** (available in the online version), we present the specific inclusion criteria. We classified the included portals based on the characteristics identified in the patient portals' online descriptions to verify existing characteristics and dimensions. Further, we aimed to find new characteristics to enhance the taxonomy, since some of these portals were designed for the organizations' particular needs. To analyze the portals' descriptions, we applied Mayring's summarizing content analysis.[35]

Results

First Research Cycle—Developing the Taxonomy

First Iteration

We built a preliminary taxonomy based on the taxonomy proposed by Ammenwerth et al[4] and purposefully selected six from seven dimensions with their characteristics to create our initial taxonomy:

$T_1 = \{$Request (with request options, no request options)
Communicate (with communication, no communication)
Remind (with reminder options, no reminder options)
Educate (with education options, no education options)
Share (with data Share options, no data share options)
Manage (with management options, no management options)$\}$

Due to the first iteration's purely conceptual nature, just four from 13 ending conditions were met (►**Fig. 1**). The method had to be repeated at least one more time.

Second Iteration

We opted to build upon the existing literature related to patient portals and identified 45 characteristics adequate to follow the determined meta-characteristic logically. We revised the taxonomy and renamed the dimensions, T_1: Communicate to T_2: E-Consult; T_1: Remind to T_2: System Notifications; and T_1: Educate to T_2: Patient Education. We changed the names of the aforementioned dimensions to more precise ones to better reflect the characteristics that the dimensions are built on after the second iteration. Responding to the characteristics that the dimensions were built on, we split the dimensions, T_1: Request into T_2: Appointment Booking and T_2: Prescription Renewal; T_1: Share into T_2: Health Monitoring and T_2: Visit Preparation; and T_1: Manage into T_2: Record Access and T_2: Records Management. Further, we created nine new dimensions. After the end of the second iteration, our preliminary taxonomy T_2 was as presented in ►**Fig. 2**. The progress of the dimensions' development is shown in ►**Fig. 3**.

Since three dimensions were split into six dimensions, and nine new dimensions were created in this iteration, the method must be repeated. Only 4 of 13 ending conditions were met, as assessed in ►**Fig. 1**. Due to the purely conceptual approach of the first two iterations, we needed to examine empirical cases to evaluate the appropriateness of the dimensions and characteristics.

Second Research Cycle—Evaluation of the Taxonomy

Third Iteration

To evaluate the taxonomy, we analyzed and classified 17 patient portals offered by software companies (►**Supplementary Appendix I**; available in the online version) and identified six new characteristics. To adequately classify the portals, two new dimensions were added. The dimension Patient Target was formed by the characteristics "outpatient" and "in & outpatient" and the dimension Study Sign-Up by the characteristics "no sign-up" and "with sign up." Since two new dimensions and four new characteristics were created in this iteration, and six ending conditions were not fulfilled (►**Fig. 1**), the method was repeated.

Fourth Iteration

In the next evaluation step, we analyzed 11 patient portals of health care providers (►**Supplementary Appendix J**;

Iteration				Ending conditions
1	2	3	4	**Objective ending conditions**
				Fundamental objective ending conditions
			•	**Collectively exhaustive**: All patient portals of interest fall into one of the categories within a dimension.
		•	•	**Mutually exclusive**: No patient portal falls into more than one category within a dimension.
				Supplementary objective ending conditions
			•	All patient portals of interest were examined.
			•	Each characteristic was assigned at least to one patient portal.
			•	No new dimensions or characteristics was added in the last iteration.
		•	•	No dimensions or characteristics were merged or split in the last iteration.
•	•	•	•	Every dimension is unique.
•	•	•	•	Every characteristic is unique within its dimension.
				Subjective ending condition
•	•	•	•	**Concise**: limited number of dimensions, charcteristics in each dimension.
		•	•	**Robust**: sufficient number of dimensions and charcteristics to discriminate among patient portals.
			•	**Comprehensive**: Identify all relevant dimensions and characteristics of an object.
•	•	•	•	**Extendible**: new dimensions and categories can be added in future.
			•	**Explanatory**: The dimensions and characteristics sufficiently explain the objects .

Fig. 1 Progress of fulfillment of ending conditions by iteration. Reproduced with permission from Roeder et al.[29]

DIMENSIONS	CHARACTERISTICS		
Care Sector Target	primary care	secondary care	generic
Portal Specialization	universal		disease-specific
Activity Monitoring	no insight		with insight
Appointment Booking	no booking	request	schedule
Prescription Renewal	no renewal	basic renewal	advanced renewal
Portal Customizability	not customizable		customizable
E-Consult	no e-consult	asynchronous	synchronous
System Notifications	no notifications	reminder	alerts
Patient Education	no education	non-personalized	personalized
Therapy Instructions	non-protocol-based		protocol-based
Health Monitoring	no monitoring	self-reported	self-tracked
Visit Preparation	no preparation		with preparation
Declaration of Will	no registration		with registration
Second Opinion	no inquiry		with inquiry
Record Access	no control	shared control	full control
Records Management	no management		with management
Health Data Amend	review	correct	delete
Health Data Up Load	no upload		with upload

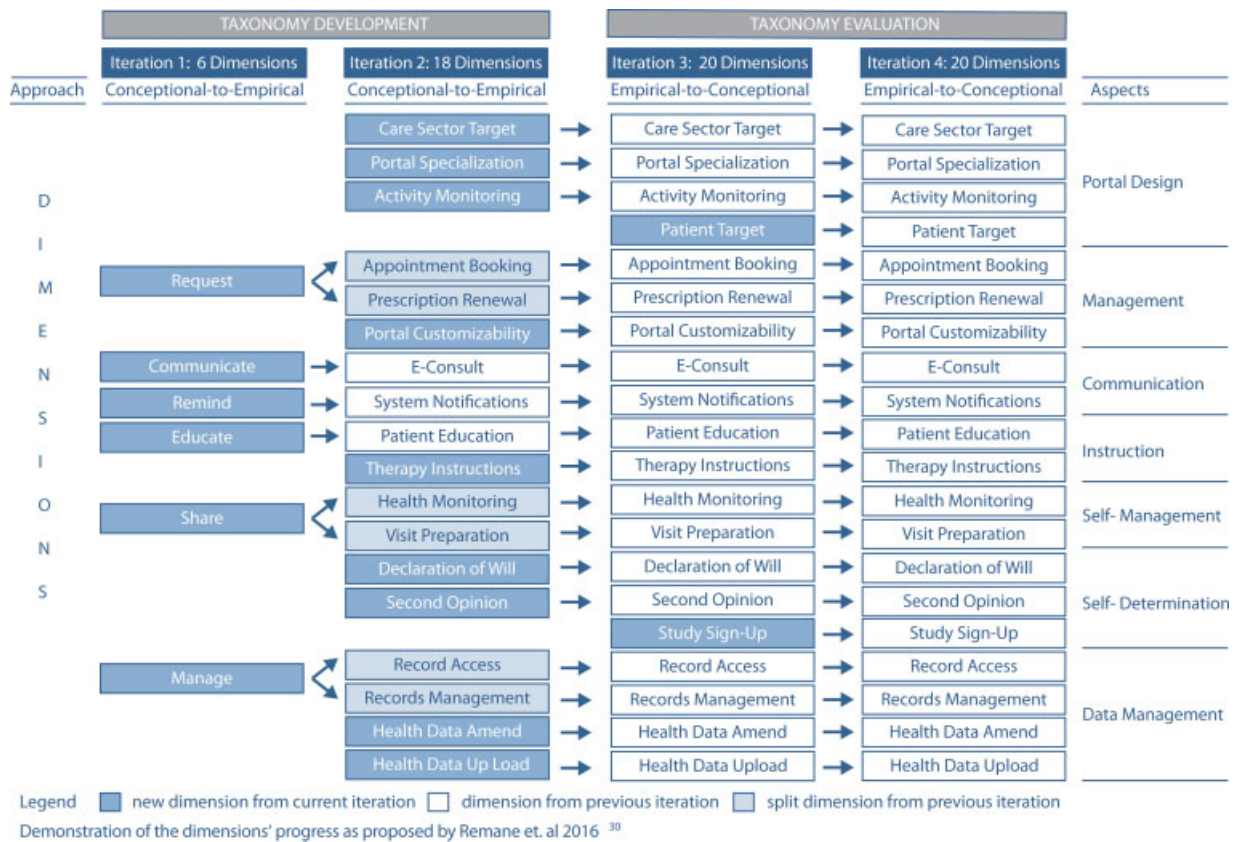**Fig. 2** Preliminary taxonomy T_2 after the second iteration.

Fig. 3 Progress of the dimensions for the patient portal taxonomy.

available in the online version). No new characteristics were found, and no dimension was changed. The evaluation conducted by iterations three and four was aimed to prove each characteristic's appropriateness by classifying real patient portals. In ►Fig. 4, we assigned the reference IDs of the classified companies and health provider portals to the taxonomy's characteristics to indicate the matching with the characteristics of the examined portals. With this, we proved that real patient portals verified all characteristics. Further, we demonstrated that all patient portals of interest fall into one category within a dimension, and that no portal falls into more than one category within a dimension.

To decide if our taxonomy is finished, we checked all the ending conditions. After examining all patient portals of interest, the taxonomy can be considered collectively exhaustive and mutually exclusive, and at least one patient portal was assigned to each characteristic as demonstrated in ►Fig. 4. Further, every dimension and characteristic is unique, and no dimension or characteristic was split, merged, or added in the last iteration. At this point, our taxonomy fulfills all objective ending conditions as defined beforehand.

We further verified the subjective ending conditions to assess if our taxonomy is useful. With 49 characteristics and 20 dimensions, the taxonomy is concise and robust, offering a limited but at the same time sufficient number of dimensions and characteristics to discriminate among patient portals. The total number of dimensions and characteristics per dimension allows future extension if new characteristics come up. The

taxonomy is, therefore, expandable. After reviewing the related scientific literature and analyzing all portals of interest, we identified all dimensions and characteristics. Therefore our taxonomy is comprehensive. Finally, the identified dimensions and characteristics sufficiently explain patient portals, as a result of which the taxonomy can be considered explanatory. At this point, the taxonomy T_4 satisfies all objective and subjective ending conditions (►Fig. 1) and can be considered finished and useful. A comprehensive description of all dimensions and characteristics is presented in ►Supplementary Appendix K (available in the online version).

How to Use the Final Taxonomy to Compare Two Patient Portals

In ►Fig. 5, we present our final and useful taxonomy and show how to perform a comparison. To make the taxonomy simple to comprehend and apply, we assigned a numbering to the dimensions and seven aspects of patient engagement. We call our taxonomy "Taxonomy of Patient Portals based on Characteristics of Patient Engagement (TOPCOP)." The comparison of two patient portals can be performed by assigning each portal's characteristics to the taxonomy's characteristics, where they match. This shows where the examined patient portals have matching or different characteristics. In performing the comparison, we demonstrated that our taxonomy is suitable to compare patient portals and that the differences and similarities become apparent.

The columns "COMPANY | PORTAL" indicate which of the 17 portals that were analyzed based on company product information (#1-17, in blue) and which of the 11 directly examined patient portals offered by healthcare providers (#18-28, in orange) match the indicated characteristics of the taxonomy's dimensions.

DIMENSION	CHARACTERISTIC	COMPANY | PORTAL	CHARACTERISTIC	COMPANY | PORTAL	CHARACTERISTIC	COMPANY | PORTAL
Care Sector Target	primary care	5,9,13	secondary care	10,14-17,18,21,27	generic	1-4,6-8,11,12,19,20,22-26,28
Portal Specialization	universal	2-4,6-12,14-16,18-21,23-28	disease-specific	1,5,13,17,22		
Activity Monitoring	no insight	1,2,5,7,9-11,13,14,21,22,25,27,28	with insight	3,4,6,8,12,15,16,17,18-20,23,24,26		
Patient Target	outpatient	5-10,13,14,18-24,26-28	in & outpatient	1-4,11,12,15,16,17,25		
Appointment Booking	no booking	14,19,20,26,28	request	2,6,11-13,22,23	schedule	1,3-5,7-10,15-18,21,24,25,27
Prescription Renewal	no renewal	1,4,12,14-18-20,22,28	basic renewal	2,5,7,10,11,21,25,27	advanced renewal	3,6,8,9,13,23,24,26
Portal Customizability	not customizable	5-9,11,12,14,16,18,19,21-25,27,28	customizable	1-4,10,13,15,17,20,26		
E-Consult	no e-consult	2,11,14,19,26,28	asynchronous	4,17,22,23	synchronous	1,3,5-10,12,13,15,16,18,20,21,24,25,27
System Notifications	no notifications	14,19,28	reminder	1,3-8,11,12,15-18,20-27	alerts	2,9,10,13
Patient Education	no education	4,5,7,11,14,15,19,20,23-26,28	non-personalized	3,9,18,21,27	personalized	1,2,6,8,10,12,13,16,17,22
Therapy Instructions	non-protocol-based	1,3-7,11-15,17,18-23,25-28	protocol-based	2,8,9,10,16,24		
Health Monitoring	no monitoring	9,11,12,18-20,23	self-reported	4,6,13,15,22,24,25	self-tracked	1-3,5,7,8,10,14,16,17,21,26-28
Visit Preparation	no preparation	11,14,19,21,23,24,26,28	with preparation	1-10,12,13,15-18,20,22,25,27		
Declaration of Will	no registration	2,3,5-10,12-14,17,18,21,22,25,27	with registration	1,4,11,15,16,19,20,23,24,26,28		
Second Opinion	no inquiry	1,3,5-9,11-14,16,17,19,20,22,24,25,26,28	with inquiry	2,4,10,15,18,21,23,27		
Study Sign-Up	no sign-up	2,4-7,9,11,13,15-17,19,21,23,24,27,28	with sign-up	1,3,8,10,12,14,18,20,22,25,26		
Record Access	no control	1,9,13,17	shared control	2,5,16,18,21,27	full control	3,4,6-8,10-12,14,15,19,20,22-26,28
Records Management	no management	1,2,4,5,7-9,13,16-19,21-28	with management	3,6,10-12,14,15,20		
Health Data Amend	review	1,4,5,8,9,12-14,16-18,21-26,28	correct	2,3,6,7,10,27	delete	11,15,19,20
Health Document Upload	no upload	6,7,9,11,12,14,18-20,22,23,25-27	with upload	1-5,8,10,13,15-17,21,24,28		

Legend: Evaluation based on company product information = nr. 1 - 17   Evaluation based on patient portals offered by healthcare providers = nr. 18 - 28

Fig. 4 Taxonomy T_4 after the fourth iteration with evaluated characteristics.

The TOPCOP Taxonomy

ASPECTS	DIMENSIONS	CHARACTERISTICS		
Portal Design	D1: Care Sector Target	primary care	O secondary care	● generic
	D2: Portal Specialization	O universal	● disease-specific	
	D3: Activity Monitoring	O ● no insight	with insight	
	D4: Patient Target	O outpatient	● in & outpatient	
Management	D5: Appointment Booking	no booking	O request	● schedule
	D6: Prescription Renewal	O ● no renewal	basic renewal	advanced renewal
	D7: Portal Customizability	O not customizable	● customizable	
Communication	D8: E-Consult	O no e-consult	asynchronous	● synchronous
	D9: System Notifications	O no notifications	● reminder	alerts
Instruction	D10: Patient Education	O no education	non-personalized	● personalized
	D11: Therapy Instructions	O ● non-protocol-based	protocol-based	
Self-Management	D12: Health Monitoring	no monitoring	self-reported	O ● self-tracked
	D13: Visit Preparation	O no preparation	● with preparation	
Self-Determination	D14: Declaration of Will	O no registration	● with registration	
	D15: Second Opinion	O ● no inquiry	with inquiry	
	D16: Study Sign-Up	no sign-up	O ● with sign-up	
Data Management	D17: Record Access	● no control	shared control	O full control
	D18: Records Management	● no management	O with management	
	D19: Health Data Amend	O ● review	correct	delete
	D20: Health Data Upload	O no upload	● with upload	

Legend   ● Company no. 1   O Company no.14

Fig. 5 Using the final TOPCOP taxonomy to compare two patient portals. TOPCOP, Taxonomy of Patient Portals based on Characteristics of Patient Engagement.
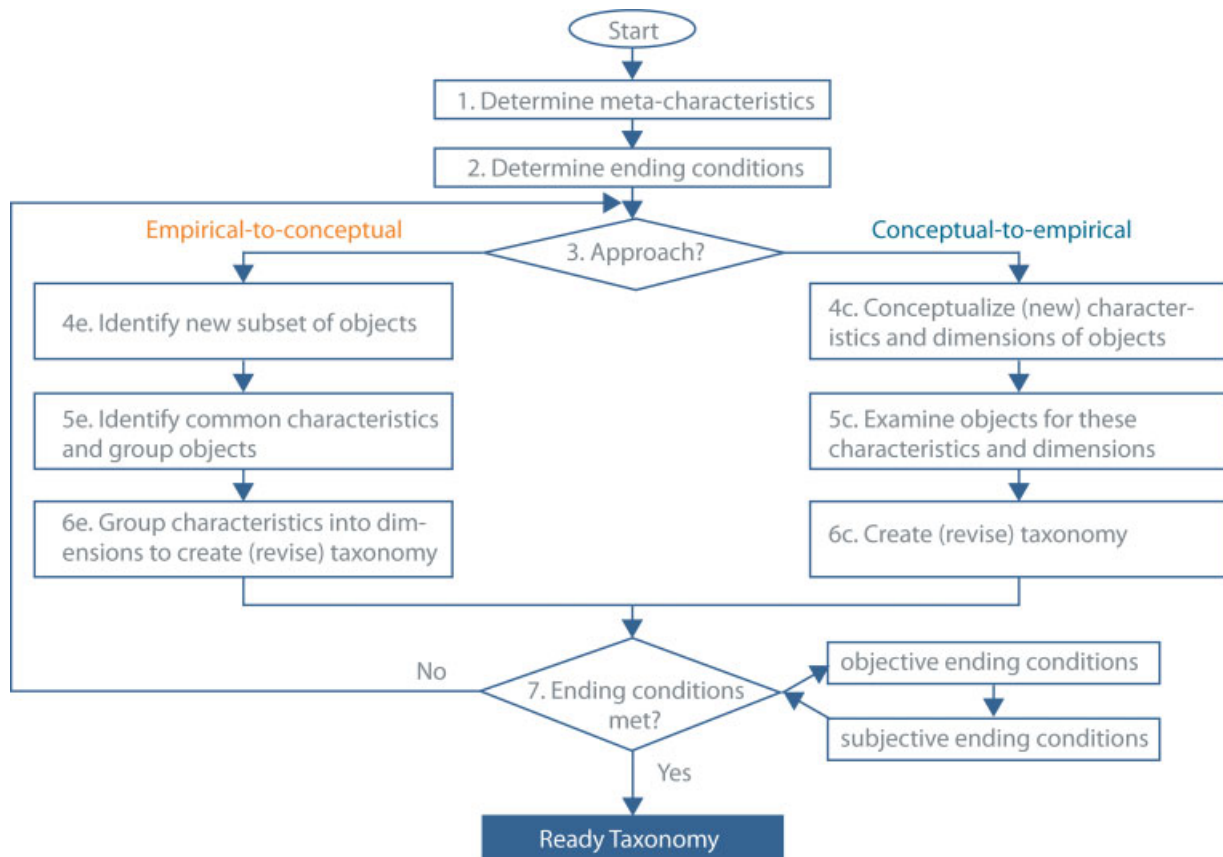
Fig. 6 The method by Nickerson et al[23] of taxonomy building. Adapted with permission from Nickerson et al.[23]

Discussion

We developed the TOPCOP taxonomy for patient portals. This taxonomy is intended to serve health information managers to classify and compare patient portals based on characteristics appropriate to promote patient engagement. To build the taxonomy, we used a formal method that defines all steps and provides conditions for usefulness. In the first cycle, we conceptionally built a preliminary taxonomy based on a literature review. In the second cycle, we empirically evaluated our taxonomy by classifying real portals and proved the appropriateness of all characteristics. Our final taxonomy results in 20 dimensions built on 49 characteristics. Fulfilling all the ending conditions, our taxonomy is considered useful.

We identified only a few other publications related to patient portal taxonomies. All the found taxonomies were developed for different purposes than the purpose defined for this research. The purpose of using a taxonomy is the central determinant in building a taxonomy, as the purpose directly shapes the resulting taxonomy.[23] A different purpose of using a taxonomy leads to a different taxonomy, and therefore the found taxonomies do not address our research aim. Thus, the TOPCOP taxonomy is the first useful taxonomy for health information managers to classify and compare patient portals focusing on characteristics promoting patient engagement. By comparing the portals, differences and similarities become apparent.

Limitations

Our approach has three limitations. The first limitation relates to the selection of software companies and health care providers to evaluate our taxonomy. Sampling was limited to companies from Germany and the United States, and to health care providers from Australia, Austria, Finland, Germany, Norway, the United Kingdom and the United States. Hence, we built our preliminary taxonomy on a broad international literature review which identified patient portals from 15 countries. The second limitation arises from the companies' low response rate when being asked to provide details on their product. We addressed this limitation by also analyzing product descriptions published online if the content was sufficiently comprehensive. However, we acknowledge that online information quality may be less precise than participating companies' information. The third limitation concerns the feature descriptions of portals available online. The available descriptions of these portals were often not quite complete, and we were unable to register with the portals as their use is restricted to register patients. However, since the intention of the fourth iteration was mainly to evaluate the appropriateness of the characteristics rather than to identify new characteristics, this limitation should not affect the outcome.

Future research should evaluate the taxonomy together with the projected users by having them apply and evaluate our taxonomy. This step is planned for the near future. Another direction for future research is to explore if the TOPCP taxonomy

can be used by health care providers from other sectors for the same purpose. Further research may also evaluate if the taxonomy can serve as starting point to create a standard framework for patient portal functional requirement specification. Since the researchers have not found a taxonomy to categorize scientific publications related to patient portals, an additional direction for prospective research may explore whether the taxonomy can be a basis to build a taxonomy to classify and compare scientific publications. Such a taxonomy would make the published research findings more comprehensible and comparable.

Our literature review was guided by the intention to gain the broadest possible bandwidth of characteristics to build our preliminary taxonomy. We selected publications related to different types of patient portals, such as tethered portals, integrated portals of health care organizations, and national patient portals. Further, we reviewed literature referring to patient portals from 15 different countries worldwide to identify suitable characteristics. Even if the sampling for the evaluation was limited to companies and health care providers from seven countries, all conceptually derived characteristics could be confirmed. Due to the wide-ranging approach in conceptually developing our taxonomy and the empirical proof of the appropriateness of the characteristics and dimensions, we consider our taxonomy suitable to compare patient portals from any country and not only from the countries we have included in our evaluation.

Conclusion

There are still various countries, such as Germany, Italy, or Switzerland, where patient portals have not found widespread use. The landscape of available patient portals is very heterogeneous, and portals significantly vary in their general types and functionalities. We developed the TOPCOP taxonomy to help health information managers efficiently compare patient portals based on characteristics promoting patient engagement. Comparing patient portals with our taxonomy may lead to a better understanding of the differences and similarities among patient portals but may also help to recognize the various application areas and scopes of the portals. Further, the taxonomy may support health information managers to more easily define which type and functionalities of patient portal they need and guide them in their selection decision.

Conflict of Interest
None declared.

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