Health and Technology (2023) 13:843–859
https://doi.org/10.1007/s12553-023-00779-7

ORIGINAL PAPER

Acceptance factors of digitalization in hospitals: a mixed-methods study

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Received: 4 August 2023 / Accepted: 27 August 2023 / Published online: 8 September 2023

Abstract

Introduction Hospitals have identified IT as a suitable mean to cope with various challenges. However, the heterogenous progress regarding digitalization cannot solely be attributed to a lack of investment. Potentially underlying socio-technical causes should be further investigated. The aim of this work is to identify factors that affect the human acceptance of digitalization in hospitals. The goal is to validate practical relevance with affected professional stakeholders as well as quantify the magnitude of the impact.

Methods The Mixed-Methods (MM) approach according to the APA Mixed Methods Article Reporting Standard (MMARS) was based on a structured literature analysis (PRISMA-ScR), expert interviews (COREQ), and a web-based survey (CHERRIES). The survey queries acceptance factors related to digitalization in hospitals. By means of a statistical analysis, correlations with the dependent variable acceptance, effect sizes and variances are investigated.

Results A total of N = 258 hospital professionals participated in the survey, with n = 155 (60.1%) female respondents, and a large share (n = 106, 41.1%) of participants from the field of nursing. Six of the 22 queried factors show a significant impact on acceptance ($P < .05$). The predictors competence and perceived benefit seem to exert the greatest influence. A multiple linear regression with $R^2 = .68$ (corrected $R^2 = .63$) shows a high goodness of fit. The predictors thus statistically influence the criterion acceptance ($F_{22,\ 193} = 13.32$, $p < .001$).

Conclusions The factors contributing to human acceptance of digitalization-related change processes in hospitals were divided into subject-, object- and context-related aspects. The factors skill, education, affinity for digitalization, future of the workplace, participation as well as the perceived benefit were identified as significant influence factors on acceptance of digitalization in hospitals.

Keywords Digitalization · Healthcare; Hospital · Change Management · Acceptance · UTAUT · Regression Analysis

1 Introduction

Healthcare institutions and particularly hospitals have identified IT as a suitable mean to cope with universal challenges like increasing complexity of services, cost and reform pressure, and shortage of skilled professionals [1]. Digital technologies indeed promise numerous opportunities including the assurance of quality of care through data access, quality and readability, the saving of valuable time through facilitation of documentation, and the reduction of repetitive tasks through automatization [2]. Progress in digitalization is partly dependent on the availability of investment funds [3]. However, the impact of digitalization on healthcare organizations as well as the response digitalization might trigger in humans that result from changes of the working environment, processes, or job profiles should also be taken into consideration [4, 5]. Within the organization "hospital" processes are particularly human-centered and determined by human engagement [6]. Human factors that affect the acceptance of employees regarding change processes have been described in the field of change management and acceptance research. Also, acceptance factors of IT fragments such as information systems in hospitals have been investigated [7]. However, the existing theory does not systematically transfer to success

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in practice when it comes to digitalizing hospitals, which is visible in the international heterogenous digitalization maturity of hospitals [8, 9]. One reason might be the theory-practice-gap that Barret and Oborn [10] described: particularly regarding the application of structural means to foster the progress in digitalization the healthcare domain is struggling to integrate theory and practice [11]. This leads to the question of whether solely a better integration of research and practice is required. Is classic change management not applicable yet to the change of the organization hospital, or the transformative character of digitalization or a combination of both? The organization “hospital” as an expert organization is admittedly peculiar [12], and the term “digitalization” rather evasive [13]. In the following we will outline the relevance of acceptance and existing approaches to describe it, driven by the fact that hospitals are strongly relying on their expert workforce.

1.1 Hospitals as expert organizations

Expert organizations are primarily built around “competencies, sophisticated procedures and complex outcomes” as described by Rasche et al. [14]. Experts are thus individuals who are highly qualified, have a strong position in the company and identify strongly with their profession [15]. They have a high degree of autonomy in decision-making and create complex services or products [16]. Originally, expert organizations were not particularly addressed in change research. Augl [17] identified this gap and suggested a framework for handling systemic change in hospitals. This framework focuses on communication and common agreement, which emphasizes the human factor. Burmann et al. examined particularly the professional group of physicians in digitalizing healthcare provision [18]. Based on this work, the triad of processes, experts of different professions and technology are further investigated in this paper.

1.2 Dimensions of acceptance and change research

Digitalization means change, and this requires acceptance. There is no consensus existing for the term acceptance in the scientific literature. It can be stated that acceptance is a multidimensional, complex construct that cannot be operationalized or measured in a standardized way. When it comes to technology and acceptance one will get in touch with technology acceptance models like the Theory of Reasoned Action [19], Technology Acceptance Model (TAM) [20], or the Unified Theory of Acceptance and Use of Technology (UTAUT) [21]. UTAUT consists of the four key constructs: performance expectancy (PE), effort expectancy (EE), social influence (SI), and facilitating condition (FC), and the moderators age, gender, experience, and voluntariness of use, which will be building blocks within this paper.

Change management literature uses diverse terms to describe the underlying acceptance process in the context of change. Wanberg and Banas [22] see the construct “openness to change” as a cognitive component of attitude. Also "readiness for change", i.e. the extent to which an individual believes the change is necessary and has sufficient capacity for it is counted as attitude [23]. Just like "commitment to change", which describes the attitude of an individual to adhere to implementation steps that are necessary for change [24]. “Resistance to change” includes both behavioral and attitude-specific aspects [25]. Ajzen and Fishbein [19] state in their "Theory of Reasoned Action" that the behavior of an individual is determined by his or her behavioral intention, which in turn is influenced by the attitude and the subjective norm. Just like the attitude and behavioral dimensions of acceptance, the presented constructs are operationalized differently, so that there is no standardized measuring instrument [26]. Since the digitalization in hospitals is a current design space this work focuses on aspects that have an impact on the dimensions attitude and behavior of acceptance.

1.3 Objectives

The aim of this work is to identify factors that affect the acceptance of digitalization processes in hospitals and to cross-validate them with experts from the domain. Thereby we answer the following research questions:

RQ1: Which factors from the change acceptance theory can be associated with the digital transformation of hospitals?

RQ2: How can the influence of these factors be weighted through a practical evaluation?

To achieve that, we follow a mixed-method approach. Firstly, we derive change-relevant acceptance factors from the literature. In order to acknowledge the complexity of digitalization itself, we focus on deriving those aspects from the theory which indicate a transformative character. These theoretically founded facets of human acceptance of digitalization are qualitatively evaluated with hospital professionals through four expert interviews. Subsequently, the magnitude of the impact, as well as practical relevance is quantitatively measured with hospital professionals. Therefore, the findings from literature and expert interviews are transferred into a web-based survey, which is conducted in cooperating hospitals. Thus, a literature-based identification and subsequent expert- and user-based evaluation of influence factors takes place.

2 Materials and methods

As an overarching method, we have chosen a mixed methods approach based on the APA Mixed Methods Article Reporting Standard (MMARS) [27]. Operationalization included a scoping review, qualitative work, and quantitative work to answer the research questions RQ1 and RQ2. The procedure was incremental, so that the results of the previous method were incorporated into the operationalization of the subsequent method.

2.1 Scoping review

To examine the state of research literature to answer RQ1, we conducted a scoping review according to the six-steps approach of Arksey and O'Malley, considering the reporting scheme for PRISMA-ScR [28] (see supplements Table S1) and the flow diagram visualization according to the PRISMA 2020 Statement [29]:

Step 1 "Research Question": Our aim was to obtain a broad overview of the evidence to support answering the research questions RQ1 as mentioned before.

Step 2 "Identifying relevant studies": To identify potentially relevant documents, the bibliographic database PubMed was searched. The search strategy was drafted by the three authors of this paper and resulted in the following search strings: (("influencing factors"[Title/Abstract] OR "human factors"[Title/Abstract] OR "factors affecting"[Title/Abstract] OR "acceptance"[Title/Abstract] OR "employee attitude"[Title/Abstract]) AND ("innovation"[Title/Abstract] OR "technology"[Title/Abstract] OR "digitization"[Title/Abstract] OR "digitalization"[Title/Abstract])) AND ("hospital"[Title/Abstract] OR "healthcare"[Title/Abstract]).

We decided against the inclusion of other databases as theoretical saturation seemed to be reached. The query results were exported into Citavi, and duplicates were removed, if these existed, based on the decision of one reviewer.

Step 3 "Study selection": To answer our research question, we included papers published between 2011 and 2021 in the English language. The retrieved papers were first examined independently by two out of the three authors based on their titles and abstracts using the inclusion and exclusion criteria. The full texts were then examined by only one reviewer. If the full texts were not available, an attempt was made to request them from the authors via ResearchGate or e-mail. Any disagreements between the authors at any stage of the selection process were resolved through discussion. For the literature selection, we defined inclusion criteria as follows.

The evaluation of acceptance factors was carried out for the target system "hospital". The target group consists of persons employed in a hospital like nurses, physicians, administrative staff and others. Evaluation of patients as the primary target group or employees in other domains were excluded. Acceptance factors were the main outcome measures. Papers about effects of perception, acceptance or attitude regarding digitalization were included. Primary measurement of clinical outcomes or evaluation of a single technology/innovation were excluded. Furthermore, papers about the description or development of methods without the naming of concrete effects were excluded. Papers with obvious quality issues were excluded.

Step 4 and Step 5 "Charting, collating, summarizing and synthesis": In the following chapter we will show the PRISMA flow diagram.

Step 6 "Consultation": The consultation was achieved through the semi-structured interviews like described in the following.

2.2 Semi-structured interviews

A first evaluation of relevance regarding the application domain "healthcare" was carried out through qualitative, semi-structured interviews with four domain experts. These experts were professionally dealing with digitalization, but with differing backgrounds: physician (> 5 years of experience), director of nursing (> 15 years of experience), head of human resources (> 10 years of experience), digital change manager (> 5 years of experience). The interviews were conducted as suggested by Gill et al. [30] and Helfferich [31]. Due to the mixed-methods approach, triangulation, i.e., capturing different perspectives on the same state the research was aimed at, with the interviews led and coded by one person from the research team. In this study, experts are those who themselves are part of the field of action. They were approached via e-mail for the initial context and the distribution of the information letter as well as the consent. For the interviews we used Microsoft Teams and its integrated audio recording function. The four expert interviews were conducted between July 14, 2021 and July 29, 2021. The final evaluation of the interviews follows the interpretative evaluation strategy for guideline-oriented expert interviews according to Meuser and Nagel [32]. The analysis was carried out using MAXQDA software. The work was aligned with the Consolidated criteria for reporting qualitative research (COREQ) reporting guideline [33]. More details can be found in the COREQ checklist (see supplement Table S2). Furthermore, see supplement Table S5 for the interview guide.

2.3 Web-based survey study

Based on the findings of the literature review as well as the interviews a web-based survey was conceptualized to investigate RQ2, the relationship and magnitude of influencing factors with people who are affected in practice through such digitalization processes in hospitals. The survey was constructed following the principles described by Dillmann et al. [34]. The survey structure is described and reported as suggested by Eysenbach's Checklist for Reporting Results of Internet E-Surveys (CHERRIES) [35] (see supplements Table S3). Both, the gathering of data and the analysis were carried out anonymously. In order to cluster the datasets accordingly, data regarding the employing hospital, professional background, age group and gender were gathered. Apart from that no potentially identifying information (access time, IP address) was stored. Participation in the study was voluntary. Consent was obtained via the confirmation function integrated in the survey software. To ensure no deanonymization is possible the researchers who analyzed the data were organizationally separated from the participating hospitals. In addition, the data analysis is carried out and reported cluster-wise.

The questionnaire was structured into six content sections and the construction sheet with the entire questions can be found as supplement Table S6. The landing page comprises a description of the survey setting and its goals, the querying organizations, the data processing procedure, and a mandatory checkbox of agreement to the described conditions before continuing with the content parts. The first content section queries structural data regarding the employing hospital and demographic data of the respondent such as gender, age, income, occupational category, years of professional experience and hierarchy level. The second survey part asks respondents to assess the penetration of digital systems in their direct working environment from a personal perspective. The subjective degree of digitalization is supposed to represent the outcome variable of the respective hospital's digitalization efforts. This is done with two questions: one asking for the perceived digitalization degree of the direct working environment, and one asking for the perceived penetration rate of an EPR on a scale from 0 (not at all) to 100 (fully digitalized/ fully implemented). The third part queries six items which refer to the general attitude towards digital technology and the digital transformation. These items were subsequently merged into one general acceptance descriptor for each participant. Parts four to six differentiate general acceptance into the identified areas subject-related factors, i.e. digital affinity of the respondent based on standardized technology affinity questionnaires [36–38], object-related factors, based on the technology acceptance questionnaire UTAUT2 [39], and context-related factors. The questionnaire comprises 41 questions aiming for a maximum of 15 min querying time. Technical functionality, editing time and comprehensibility were tested before the survey launch with a group of ten participants. The pretest did not require any further adjustments to the questionnaire. The distribution of responses was subject to a wide variance and was not concentrated in the centre, so that the odd-numbered, five-point Likert scale was retained. All survey questions were not mandatory to ensure no responses were enforced.

2.3.1 Recruitment

The target group of the survey were hospital employees. In cooperation with the Krankenhausgesellschaft Nordrhein-Westfalen (KGNW, hospital society North Rhine-Westphalia) and the Fraunhofer Institute for Software and Systems Engineering ISST selected hospitals in North Rhine-Westphalia were invited to participate. The survey was distributed among the hospital employees through selected channels of the respective hospital management. The survey was active from September 16, 2021 to October 11, 2021.

2.3.2 Data analysis

The outcome variables of the survey were queried in the factor-related survey parts four to six, where items were designed as five-point Likert-type ordinal scales. These Likert-type items are comprised into factor-specific Likert scales (interval scale), in order to carry out arithmetic operations [40]. The demographic data (survey part one) includes only nominal scales (for example gender, occupational category, age). Survey part two entails two ratio scales querying the degree of implementation of digitalization artifacts in the direct working environment. Following the descriptive examination of results, the acceptance-factors are investigated for differences in mean value regarding the demographic nominal values. Since the Kolmogorov-Smirnoff-Test did not show a normal distribution of the data, the Kruskal-Wallis-Test is used [41]. The Kruskal-Wallis test is a parameter-free test used in an analysis of variance to test whether independent samples vary with respect to an ordinal scaled variable. A Dunn-Bonferroni post hoc analysis reveals the difference in magnitude and between the respective groups [42]. Following that, all factor-areas, acceptance, and perceived degree of digitalization in the direct working environment are examined in order to find correlations using the Pearson correlation coefficient [43] for metric scales and the η coefficient for nominal scales [44]. Subsequently, the magnitude of influence of the subject-related, object-related, and context-related factors on acceptance are determined through a multiple linear regression. Linear relationship between variables, the absence of outliers, multicollinearity,

homoscedasticity and the normal distribution of the residuals are studied as a prerequisite [45]. The survey results are statistically analyzed using the SPSS Software Version 27.0.

2.3.3 Data inclusion

A total number of 258 participants submitted the survey, of which 102 rows contained incomplete questions. However, all submitted surveys were included in the analysis, provided the fact that the respondent has had a relevant professional engagement in a hospital environment.

3 Results

The results are described along the incremental mixed methods approach and result in a theoretical effect model for acceptance of digitalization in hospitals.

3.1 Scoping review

The result of the scoping review is shown graphically in the following PRISMA 2020 flow diagram (see Fig. 1).

A total of 1159 records were identified after applying the search term in PubMed. After reviewing the titles and abstracts of the papers, 951 records were excluded. Further filtering was subsequently performed by reviewing the remaining 208 full texts. In both steps mentioned above, the inclusion criteria referred to in the method description were checked. The most reports were excluded because the described target system of evaluation was not a hospital (65/198). Since our focus lies on the question of the acceptance of digitalization in hospitals, we decided to exclude them. This was also the case if the participants were not primarily hospital employees (5/198). Incorrect methods or outcome measures, such as the lack of acceptance endpoints or the focus on clinical outcomes also led to exclusion

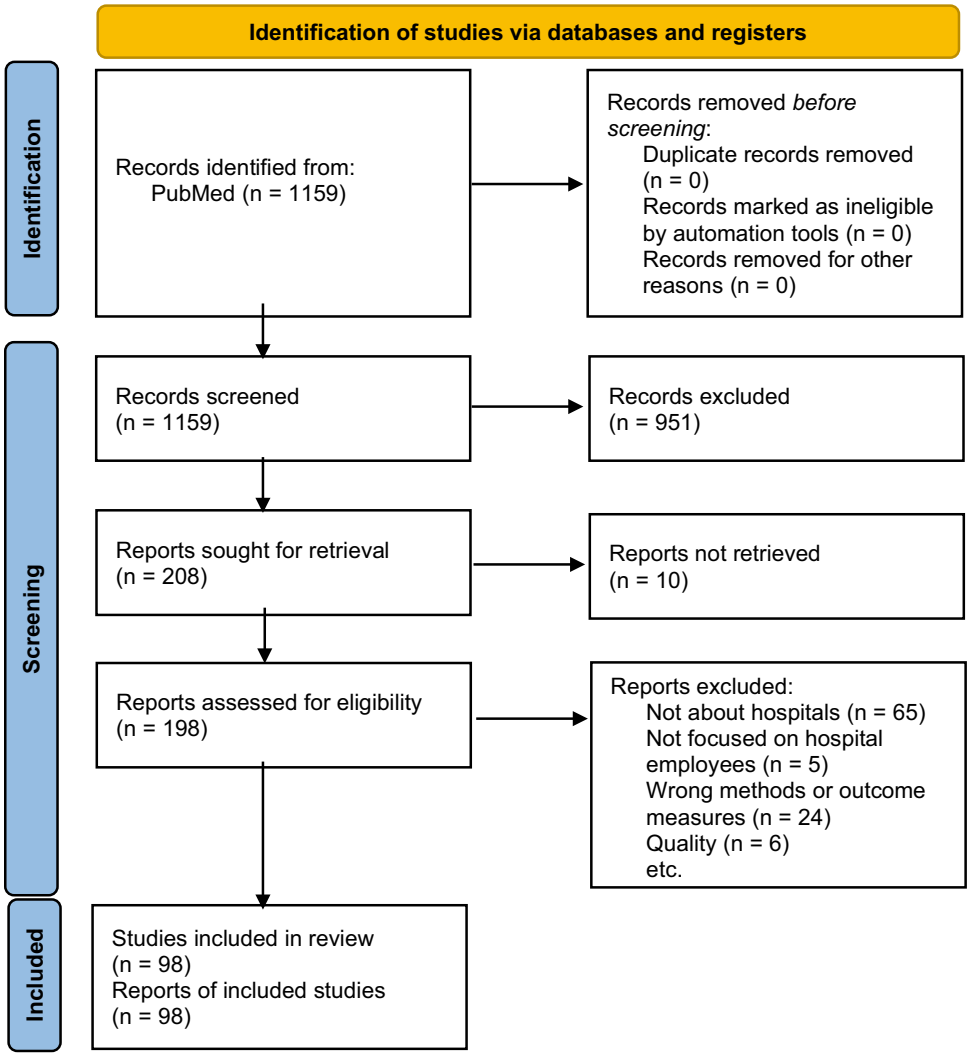

Fig. 1 Flow diagram of the scoping review according to PRISMA 2020 [29]

(24/198). Eventually, 98 papers were included for further analysis.

For the synthesis, a conceptualization of the content of the 98 papers was carried out in analogy to the recommendations of Webster and Watson [46] with the aim of sorting them along topics or categories. The authors followed an incremental process by building a concept map for the final derivation of three categories with 22 factors, as described in Table 1 below. The overall result of the full-text screening can be found as supplemental material Table S4.

Subject-related factors include attitudes, norms and values, emotions, and sociodemographic variables. With regard to the hospital context and digitalization-specific elements, Handayani et al. [7] found in their study that non-technological factors, i.e., human and organizational variables, have the greatest impact on employee attitudes.

Object-related factors bring the specific characteristics of the acceptance object into focus. Often, in the relevant literature, a specific technology or software, or a specific system such as a hospital information system, is considered the object of acceptance. In this case, differentiated technical factors that affect user acceptance are often investigated.

Factors related to the acceptance context are all those aspects which are neither related to the acceptance subject nor to the acceptance object. Since the context-related factors also include the organizational and situational framework conditions, they are also sometimes in the literature referred to as organizational factors [56], setting variables [57], environmental characteristics [63] or situational variables [23].

3.2 Qualitative research

The main focus of the interviews lies on examining the attitude or behaviour of hospital employees toward digitalization processes or differences perceived by the interviewees. In general, the four experts describe a positive, open attitude toward digitalization processes. The majority of hospital employees supposedly show acceptance regarding the digital transformation. However, the interviewees note that there is also scepticism, resistance and defensiveness among some employees. A small proportion of the hospital staff is therefore more likely to be unaccepting and rejecting. A comprehensive overview of the subject-, object- and context-related factors is shown in Table 2.

Regarding the subject-related factors, demographic aspects play a role according to the experts. In particular, the age factor should be considered here. With regard to the factors relating to the acceptance subject and thus to the employee himself, demographic aspects play a role according to the experts. In particular, the age factor should be taken into account here.

In the context of the object-related aspects, the experts defined the criteria that are part of the perceived benefit factor which are mentioned above.. For example, the technologies should make life noticeably easier and less stressful for users and contribute to an increase in efficiency. In addition to the perceived benefits, the experts also refer to the perceived user-friendliness or usability as a factor that influences the acceptance of hospital employees. For example, the new systems and technologies should be as easy to understand and as intuitive as possible, so that users do not need long periods of training.

Support for employees in the ongoing digitalization process is seen as one of the most important contextual factors affecting employee acceptance. Especially at the beginning of the implementation phase, it seems important to accompany employees closely and provide sufficient support in the form of personnel and time resources. In addition, good communication, including the transparent dissemination of information, has also proved to be a key factor influencing acceptance of digitalization processes.

3.3 Preliminary effect model of acceptance for digitalization in hospitals

As a result of the literature review as well as the qualitative research we derived a first version of the effect model of acceptance for digitalization in hospitals, as depicted in Fig. 2.

In our theoretical effect model, the factors of the three categories are related to the variable "acceptance". This in turn is determined in our model by attitude and behaviour, as described in the introduction. Acceptance, in itself, is the predictor of successful digitalization in hospitals. The task of the quantitative analysis is to validate and resolve these structural equations.

3.4 Respondent's statistics of the web-survey

A total of 258 survey sets were included in the analysis. Two-thirds of the respondents were female (155/258, 60.1%) and the majority was employed in full-time (166/258, 64.3%). 83 of 258 respondents were employed in a leading position (32.2%), while the years of working experience were roughly equally distributed. The detailed respondent's statistics are displayed in Table 3.

Regarding the two perceived degree of digitalization outcome variables the mean degree of implementation of an electronic patient record was estimated with a mean of 39.4 and the digitalization degree of the direct working environment with a mean of 42.2 (n = 244). Both values withhold a wide spread of roughly 30. This is particularly interesting considering the fact that 168 respondents were from the same hospital. The two variables show a significant

Table 1 Three categories with 22 factors derived from the scoping review

Category	Factor	Relevance described in	No. of papers
Subject-related	Age	In some studies, the age factor is emphasized. Older people are generally more averse to new technologies than younger people. [47, 48].	13
	Gender	Some contradictory theories and results can be found regarding the gender. It is often assumed that men tend to have a more positive attitude toward information and communication technologies [49–51].	8
	Digitalization affinity	A person's affinity for technology influences adoption, as shown by TAM or even UTAUT [21, 52].	21
	Education	This relates to the type of education. There are differences in the type of educational qualification, whereby there is always a cofounding effect due to the profession [53, 54].	10
	Skills and competences	Confident and targeted use of digital technologies requires digital skills. In the Lilien model of e-health literacy, for example, reading and writing skills, computer skills, media literacy, scientific literacy, information literacy and health literacy are skills taken into account [23, 55–57].	38
	Openness to experience	Perceived behavioural control is a factor influencing openness to organizational change processes in general, since change often means stress. A high level of perceived competence and perceived behavioural control are considered to be criteria that increase individual readiness for change [22, 58, 59].	5
	Experience with change processes	Positive experiences with change processes in the past activate positive attitudes. Past experiences of healthcare workers influence the use of digital technologies in their working environment [26, 57, 60].	7
	Income	Isolated evidence is found that income may have an impact on acceptability [61].	1
Object-related	Perceived benefit	The Technology Acceptance Model (TAM) and its further developments pursue the goal of predicting the acceptance of information systems. Perceived usefulness in this context is seen as the extent to which the user believes that using the system will improve his or her own performance [21, 62, 63].	54
	Perceived ease of use	Perceived ease of use measures the extent to which the user believes that operating the system comes without much effort [21, 62, 64].	49
	Compatibility/interoperability	When selecting an e-health system, attention must be paid to compatibility with other existing systems and workflows. In the context of innovation characteristics, the term interoperability is often used synonymously [48, 57, 62].	14
	Adaptability	Rigid, predefined processes within digital innovations can provide guidance on the one hand but can also reduce autonomy on the other, which in turn can limit well-being [65, 66].	4
	Speed/availability	The performance and accessibility of a technical system have a direct influence on work processes. If these are lacking, satisfaction and, in the same course, acceptance decline [67, 68].	18
	Susceptibility to failure	Increasingly, the hopes and fears of employees regarding the consequences of the digital transformation are coming into focus. Technological shortcomings are mentioned, such as a lack of data security or data protection, or the susceptibility of digital systems and technical innovations to failure [47, 69].	8
	Work/time expenditure	Additional time-intensive functions can lead to higher time investments in IT-supported documentation. According to this view, digitalization tends to bring additional burdens and growing pressure to perform [47, 69].	14
	Future of the workplace	Digitalization is changing work and the processes anchored in it. It increases the attractiveness of the workplace, but also the risks of being replaced [70, 71].	17
	Costs	As hospitals are exposed to high economic pressure, challenges such as the most economically efficient mode of operation, expenditure savings and increased competition mean that the cost factor is always in the focus of interest [48].	11

Table 1 (continued)

Category	Factor	Relevance described in	No. of papers
Context-related	Participation	Participation and involvement in decision-making within the framework of such projects are among the situational variables that lead to less negative and cynical reactions among employees, in addition to greater willingness to support change processes [7, 23].	22
	Communication/information	In addition to participation in the change process, effective communication of upcoming changes is a factor that can prevent uncertainty and resistance to them [7, 72, 73].	19
	Organizational culture	An organizational culture or climate characterized by employee participation, transparent information flows and effective management strategies can have a positive influence on employees' attitudes toward organizational change processes [23, 74, 75].	23
	Training	Through training, employees can be supported by the organization in the context of the digital transformation, so that they can further develop their digital skills or their abilities in dealing with new innovative technologies [28, 76].	37
	Supporter/Multipliers	There can be supporting persons both internally and externally. Key users are often involved in the introduction of systems [77, 78].	15

correlation ($r = 0.78$, $p < .001$). The general digitalization acceptance descriptor has no visible relationship with both the EPR penetration rate ($r = -0.08$, $p = .276$) and the digitalization degree of the direct working environment ($r = -0.03$, $p = .651$).

In the following the general digitalization acceptance descriptor is investigated in order to find out differences within the demographic groups queried in survey part one. Since the variable is not normally distributed and several groups are compared, the Kruskal-Wallis-Test is used. Significant differences are found between gender groups male and female ($z = 3.3$, $P = .003$), with the male group showing higher acceptance rates than females. The diverse group shows no difference. Regarding age associations, only the age group 26 – 35 years shows significant differences compared to the age groups of 46 – 55 years ($z = 4.2$, $p < .001$) and the group aged 56 and over ($z = 4.4$, $p < .001$), with younger participants achieving higher acceptance rates. The same tendency is shown regarding years of working experience: the group with more than 30 years of working experience shows significantly lower acceptance rates than the groups with less than 6 years ($z = 3.6$, $p = .004$) and between 6 – 10 years ($z = 3.3$, $p = .011$). Occupational staff categories reveal significant differences regarding the acceptance descriptor only between nursing staff and IT ($z = 3.0$, $p = .048$), with higher rates in the latter group.

Table 2 Representation of various subject-, object-, and context-related factors as a percentage of the total number of references of all contextual factors in its group

Subject-related		Object-related		Context-related	
Factor	%	Factor	%	Factor	%
Age	27	Time expenditure	34.4	Support	17.4
Gender	12.6	Perceived usefulness	12	Communication	16.5
Competence	10.8	Future of workplace	9.6	Participation	14
Openness	9	Perceived ease of use	8.8	Multipliers	9.9
Education	7.2	Costs	8	Training	9.9
Income	5.4	Speed of system	4.8	Project Management	5.8
Experience	5.4	Adaptability	4.8	Enthusiasm	5.8
Willingness to experiment	4.6	Focused on patient	4	Fears	5.8
Future-orientation	3.6	Control	3.2	Identification	5
Digitalization affinity	3.6	Availability	3.2	Cultural change	5
Culture	2.7	Interoperability	3.2	Vision	4.1
Curiosity	2.7	Competitiveness	2.4	Private environment	0.8
Self-fulfillment	2.7	Safety & security	0.8		
Family status	2.7	Disinfectability	0.8		

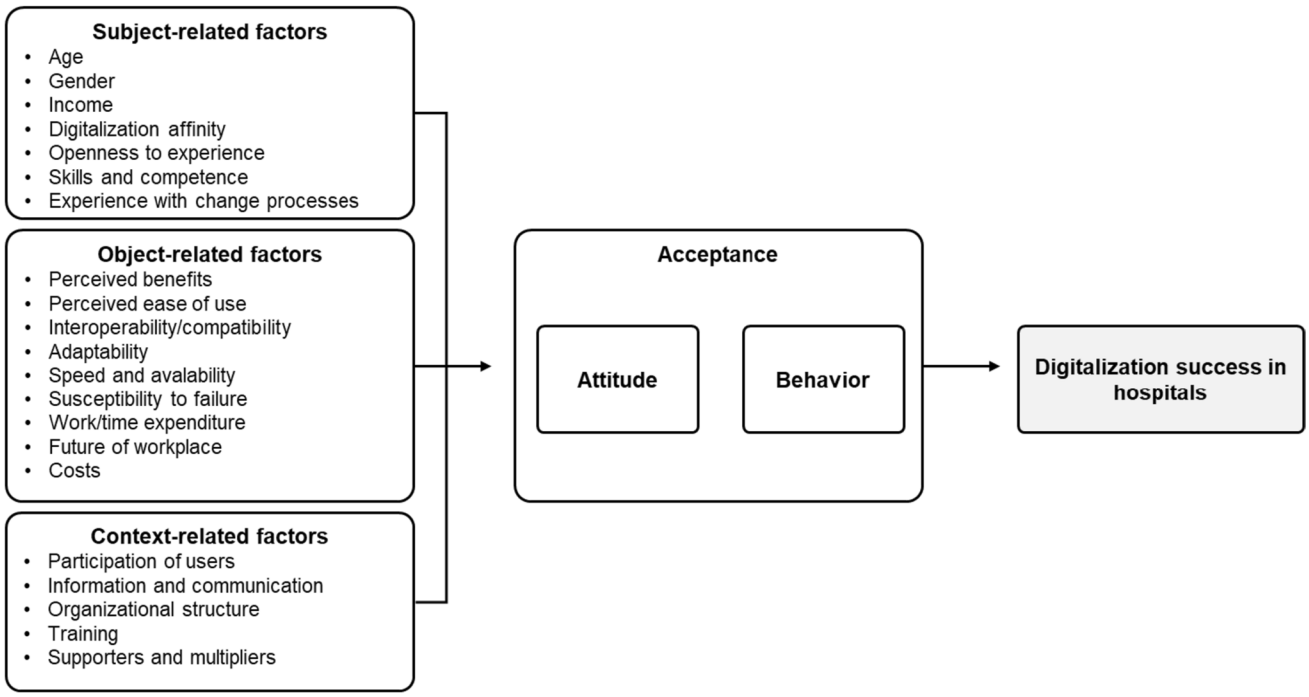

Fig. 2 Preliminary effect model of acceptance for digitalization in hospitals

Regarding differences between volume of employment the part-time group (≤ 50%) shows a significant lower acceptance rate than the full-time group ($z = 2.7$, $p = .048$). Among the education groups the highest degree obtained secondary school showed a lower acceptance rate compared to the master's group ($z = 3.7$, $p = .004$). Regarding income and leading position groups no differences between the acceptance descriptor means are found.

To identify the relationship between the acceptance descriptor and the nominal variables gender, age, income and education the η coefficient is calculated. The results are depicted in Table 3. The effect sizes η^2 are relatively low: for the strongest correlation of $\eta = .34$ for the variable age 12% of the variance of the acceptance descriptor can be attributed to that factor.

For the investigation of relations between subject-, object-, and context-related variables and acceptance the Pearson correlation coefficient r is calculated as well. By doing that, a correlation for most of the investigated factors with a level of significance of 1% is revealed. Only the three factors training, organizational culture, and interoperability correspond with a significance level of 5%, while cost, speed and openness do not correlate at all with acceptance. The correlation coefficients across all queried factors are displayed in Table 4.

After verifying the assumptions and prerequisites linear relationship between the variables, the absence of outliers, multicollinearity, independence, homoscedasticity, and normal distribution of the residuals, a multiple linear regression is carried out. With $R^2 = .68$ (corrected $R^2 = .63$) the regression model has a very high goodness of fit [79]. 63% of the variance of the dependent variable acceptance can be explained by the 22 predictors. According to Cohen, this means high or strong variance elucidation. The queried predictors thus statistically predict the criterion acceptance ($F_{22,\ 193} = 13.32$, $p < .001$). Six of the total 22 factors also exert a significant influence on acceptance ($P < .05$). The predictors competence and perceived benefit seem to exert the greatest influence on acceptance, while participation shows a negative relation with acceptance. The coefficients of all predictors are listed in Table 5.

The following Fig. 3 shows the regression model together with its coefficients. In the presentation, a distinction is made between subject-related, object-related, and context-related predictors.

Table 3 Effect size of correlation between acceptance and nominal demographic variables

Variable 1	Variable 2	η	η^2	p
Age	Acceptance	*.34*	.12	<.001
Gender	Acceptance	*.20*	.04	.017
Income	Acceptance	.17	.03	.317
Education	Acceptance	*.28*	.08	.005

η effect size, $\eta 2$ (partial) Eta-squared, p probability value

Table 4 The correlation coefficients across all queried factors and acceptance

	ACC	OPE	SKI	AFF	WTE	FUT	ADA	SUS	INF	EDU	PAR	SUP	CUL	EXP	BEN	EOU	INT	SPE	COS
ACC	1.00																		
OPE	-.11	1.00																	
SKI	.61**	-.19**	1.00																
AFF	.50**	-.08	.52**	1.00															
WTE	.43**	-.07	.30**	.21**	1.00														
FUT	.33**	-.17*	.22**	.14*	.50**	1.00													
ADA	.30**	-.07	.26**	.11	.29**	.18*	1.00												
SUS	.25**	-.05	.24**	.11	.11	.05	.49**	1.00											
INF	.24**	-.05	.22**	.10	.07	.04	.45**	.50**	1.00										
EDU	.18*	-.17*	.18*	.06	.08	-.01	.41**	.46**	.69**	1.00									
PAR	.21**	-.16*	.21**	.22**	.18*	.13	.34**	.40**	.54**	.52**	1.00								
SUP	.27**	-.13	.28**	.17*	.17*	.13	.53**	.63**	.71**	.62**	.58**	1.00							
CUL	.15*	-.06	.09	.14	.03	.00	.28**	.38**	.50**	.49**	.54**	.59**	1.00						
EXP	.19**	-.19**	.15*	.06	.23**	.18**	.29**	.17*	.09	.22**	.22**	.24**	.18*	1.00					
BEN	.56**	-.05	.36**	.33**	.42**	.26**	.41**	.29**	.29**	.20**	.26**	.34**	.20**	.20**	1.00				
EOU	.37**	-.01	.34**	.20**	.33**	.22**	.43**	.27**	.36**	.17*	.18*	.36**	.18*	.04	.39**	1.00			
INT	.18*	.01	.20**	.08	.07	.06	.50**	.46**	.38**	.25**	.21**	.40**	.31**	.07	.27**	.50**	1.00		
SPE	.11	.01	.04	.06	.28**	.28**	.11	.07	.06	.04	.11	.10	.06	.05	.15*	.07	.09	1.00	
COS	-.03	-.01	-.10	-.06	.32**	.14*	.08	-.03	.01	.01	-.01	-.09	-.01	-.03	.00	.09	.07	.23**	1.00

*The correlation is significant at the 0.05 level (2-sided); **The correlation is significant at the 0.01 level (2-sided)

Table 5 Effect size of correlation between acceptance and nominal demographic variables. Regression coefficients for 22 queried predictors for the dependent variable acceptance

Predictor	Abbreviation	*B*	SD	*β*	*p*
Gender	GEN	-.14	.08	-.11	.079
Age	AGE	-.04	.03	-.09	.128
Income	INC	.01	.03	.03	.655
Education	EDU	.07	.03	.15*	.014
Openness to experience	OPE	.05	.05	.06	.296
Skill (Competence)	SKI	.30	.06	.34**	<.001
Digitalization Affinity	AFF	.14	.04	.21**	.001
Work/time expenditure	WTE	.06	.04	.10	.138
Future of the workplace	FUT	.13	.06	.14*	.027
Adaptability	ADA	-.04	.06	-.05	.528
Susceptibility to failure	SUS	.04	.05	.05	.476
Communication/information	INF	.08	.06	.11	.192
Training	TRA	.04	.05	.06	.440
Participation	PAR	-.15	.06	-.18*	.012
Support/multipliers	SUP	-.08	.08	-.1	.277
Organizational culture	CUL	.06	.05	.07	.281
Experience with change processes	EXP	.09	.05	.11	.057
Perceived benefit	BEN	.17	.05	.24**	<.001
Perceived ease of use	EOU	.05	.05	.07	.343
Interoperability	INT	.01	.05	.01	.871
Speed/availability	SPE	-.01	.03	-.02	.679
Costs	COS	-.01	.03	-.01	.828

**B* unstandardized beta, *SD* standard deviation, *β* standardized beta, *p* probability value

Based on the results of the quantitative survey of hospital employees, the impact model was evaluated and revised once again. Only those influencing factors were included that have a significant influence on acceptance. These are digitalization affinity ($\beta = .21$; $p = .001$), competencies ($\beta = .34$; $p < .001$), education ($\beta = .15$; $p = .014$), perceived benefits ($\beta = .24$; $p < .001$), assumptions about the future of the workplace ($\beta = .14$; $p = .027$), and participation or participation of users ($\beta = -.18$; $p = .012$).

3.5 Final effect model of acceptance for digitalization in hospitals

The result of the incremental mixed methods process to answer the research questions RQ1 and RQ2 is shown in Fig. 4.

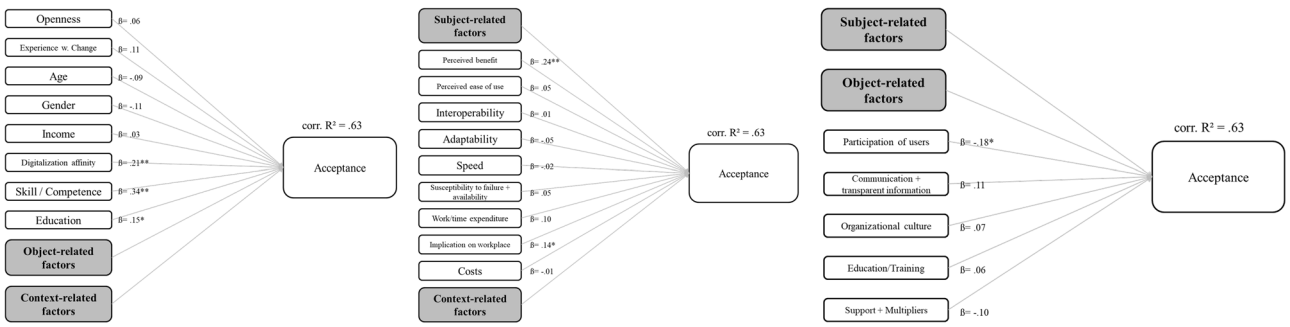

Fig. 3 Regression model with coefficients distinguished between subject- (left), object- (middle) and context-related predictors (right). Full images are available as supplemental Fig. S1

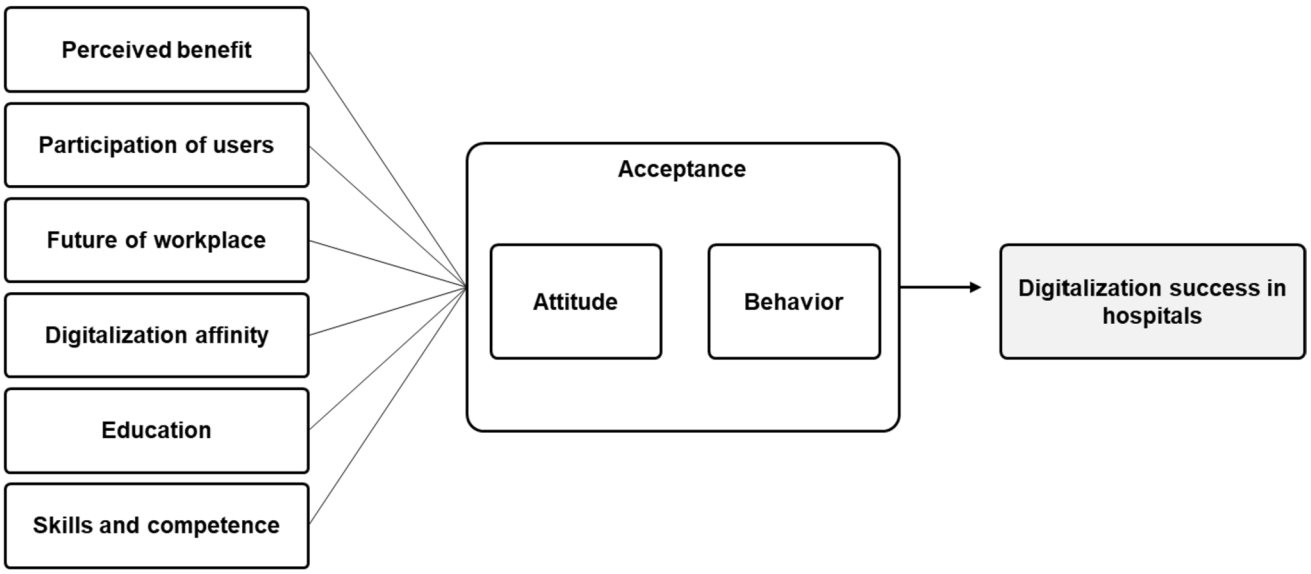

Fig. 4 Final effect model of acceptance for digitalization in hospitals

The initial 22 factors from three categories were reduced to seven factors which have a significant influence on the variable "acceptance".

4 Discussion

In the following we will discuss the results regarding our initial research questions RQ 1 and RQ2 by summarizing the principal results and afterwards cross referencing these to the state of research.

4.1 Principal results

In a literature search and four initial expert interviews a theoretical influence model for acceptance of digitalization-related change processes was set up for a quantitative evaluation with participants from practice. During the expert phase some of the in the literature identified factors (self-efficacy, emotional intelligence, the "Big Five" personality factors or leadership) were assessed to be less relevant for particular digitalization processes in hospitals and were thus left out for evaluation. Variables such as digitalization affinity or competencies regarding the use of technologies were included in this phase and in the further analysis. In the following, a web-based survey study with 258 healthcare professionals as respondents queried the relevance and magnitude of the identified factors.

The test for differences in acceptance trends revealed that mean acceptance values across members of different groups differed significantly in some cases. E.g., younger employees have significantly higher acceptance values than older employees. Similar findings were made in the context of work experience. Men showed significantly higher acceptance tendencies than women, while employees with a higher academic degree also showed significantly higher tendencies of acceptance than graduates of a secondary school. The following correlation analyses of the subject-, object- and context-related factors with the variable acceptance are largely consistent with the findings of the assumptions derived from literature research and expert interviews. Excepting the four aspects income, openness to experience, speed of systems and costs, the factors of the proposed impact factors all correlate significantly with acceptance of digitalization processes. The aspects skill, digitalization affinity and perceived benefit showed the highest correlation coefficients.

The Pearson correlation on the other hand showed no correlation between acceptance and the digitalization outcome variable. Digitalization outcome was measured through the two variables perceived EPR penetration rate and the perceived degree of digitalization in the direct working environment. The multiple linear regression showed the factors skills, education, affinity for digitalization, future of the workplace, participation as well as the perceived benefit as significant influence factors on acceptance of digitalization processes in hospitals. Participation was the only factor which showed a negative relation.

4.2 Comparison with the state of research

The digitalization of healthcare organizations like hospitals is highly complex. Medical professionals often perceive the administrative interests (economically driven) of hospitals as

being discrepant with their professional interests ("ethics") [80]. The striving for autonomy in this conflict leads to a limited interest of experts in administration-related tasks. That manifests itself in impaired interfaces in the course of treatment [81]. With respect to the literature review most of the papers discussed acceptance related to a single technology like Electronic Medical Records (EMR) or Hospital Information Systems (HIS). Or et al. [82] started to generalize the adaption to achieve a fit between physicians and EMR by describing a layered model from users (literacy, trust), technology (interface, function), work routines, organization to external environment. Thus, there is a large fit with our results.

Additionally, expert professions tend to pursue preservation of their scope of responsibility [83]. Expert organizations are thus a suitable space for "individual further development of knowledge in the direction of more specialization, but not for integrated, interprofessional learning processes across the boundaries of one's own profession and the subsystem to which one belongs" [83]. The continuous cooperation of disciplines and other professional groups in hospitals is challenging, but necessary to provide the best possible treatment [84]. A digitally supported process raises integration and transparency across all contributors to a new level [14]. Child supposes that especially experts are likely to be suspicious towards changes of their established routine [85].

Within this study we found a general curiosity and interest for digitalization of their professional environment within the participating group of healthcare professionals. The first evaluation of theoretical findings through interviews with experts from the domain showed that theoretical influence factors on acceptance of digitalization-related change processes in hospitals were not encompassing. This was confirmed in the correlation analysis as well as in the multiple regression. In contrast Cucciniello et al. [86] clearly stated the relevance of a managed process including communication and change management.

We also found that the subjective perception of the degree of digitalization of the direct working environment was rather reserved. At the same time both parameter of the personal perception of digitalization status within the hospital withholds a great variance. The perceived implementation rate of an EPR suggests this, considering the fact that 168 responses from the same hospital with assumingly a common reference base resulted in a standard deviation of approx. 30 points. Obviously subjective perception varies widely. One reason for this could be that a renowned definition of digitalization is not existent.

Interestingly, the factor participation showed a negative relation with acceptance of digitalization processes in hospitals. In literature, participation or involvement in change is described to lead to less negative and cynical reactions among employees [23]. In previous studies, participation is also discussed ambivalently, especially in combination with other factors which serve as a proxy [87]. From the gathered data we can assume, that participation, covariates, enabler and dependencies in digitalization-related change processes in hospitals require further investigation.

Surprisingly, several object- and context-related factors were not significantly impacting acceptance. Most of the literature mentioned the relevance of hospital infrastructure, human resource management, financial resources and leadership styles [86, 88, 89]. One explanation might be the high participationrate of one hospital, resulting in a missing variance. Structural, contextual, and organizational factors as well as human factors have to match together to foster the implementation of Health Information Systems (HIS) and poor leadership, inadequate end-user engagement and unrealistic timelines has to be prevented [89].

Regarding personality and state as well as traits Strudwick et al. [90, 91] underpin their relevance as there is an interplay between optimism, innovativeness, insecurity, and discomfort, computer anxiety, self-efficacy, and experience. Furthermore, they discussed the relevance of influencing external variables. This is interesting, as it would have led us to expect a higher degree of interaction between subjective and contextual factors in our model. In future research one should investigate more on the interrelationship between our categories.

4.3 Limitations

One possible bias is that the surveyed individuals give socially desirable answers [92], to present themselves or their professional group in a positive way. However, we assumed presence of this behaviour across all included groups. It must be pointed out that the representativeness of the results is limited because the participants in the web-based survey participated voluntarily and proactively, which entails a risk of self-selection bias [93]. The relation of acceptance of digitalization processes in hospitals and the actual digitalization success remains unclear. We queried two variables to assess this, which turned out to withhold too much of variance to derive meaningful insights. Also, no assumptions regarding the transfer from acceptance to supportive behaviour can be made. Furthermore, we have to argue that the variance of hospitals was very low and most responses came only from one hospital.

5 Conclusions

The evaluation with the relevant professional group showed that factors contributing to human acceptance of digitalization-related change processes in hospitals can be divided into subject-related, object-related, and

context-related aspects. Subject-related factors refer to the acceptance subject, i.e., the hospital employee himself. This category includes skills and personality traits as well as demographic aspects such as age or gender. The object-related factors are divided into the technical aspects of a specific application on the one hand and assumptions about the effects of digitalization in general on the other. The context-related factors include the way in which digitalization processes are handled in the respective hospital. The factors skills, education, affinity for digitalization, future of the workplace, participation as well as the perceived benefit showed the strongest relation and were thus in this study the dominating influence factors on acceptance of digitalization processes in hospitals.

Supplementary Information The online version contains supplementary material available at https://doi.org/10.1007/s12553-023-00779-7.

Acknowledgements We would like to thank the Krankenhausgesellschaft Nordrhein-Westfalen e.V. for providing access to their member hospitals for recruitment.

Authors contribution ABu conceived the study. SSc researched literature and carried out expert interviews. ABu and SSc were involved in protocol development, interview partner recruitment and data analysis. ABu wrote the first draft of the manuscript. SMe was responsible for the methods as well as supervision and re-writing. All authors reviewed and edited the manuscript and approved the final version of the manuscript.

Funding Open Access funding enabled and organized by Projekt DEAL.

Data availability Requests can be addressed to the corresponding author and will be assessed individually.

Declarations

Ethical approval Ethical approval was not sought for the present study after consultation with the data protection officer. Due to the content of the questionnaire and the anonymous data processing, no implications could be identified. Participation was voluntary and all participants were employees working for members of the KGNW.

Consent to participate All methods were carried out in accordance with relevant guidelines and regulations. Informed consent was obtained from all subjects involved in the qualitative (signed PDF, written) and quantitative study (through survey software, checkbox).

Consent to publication The manuscript doesn't contain any individual person's data. Qualitative and quantitative data have been anonymized.

Conflict of interest Not applicable.

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