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Medical Students' Attitudes and Competence in eHealth and Digitalization – A Comparative Cross-Sectional Study in 2016–2022

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Medical Students' Attitudes and Competence in eHealth and Digitalization – A Comparative Cross-Sectional Study in 2016–2022

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Abstract

Background: Modern healthcare systems worldwide are facing challenges, and digitalization is viewed as a means to strengthen healthcare globally. As digitalization in healthcare demands adjustments in practices, policies, and workflows, assessing healthcare professionals' competencies is crucial for effective integration into their work environment.

Objective: The aim of this study was to analyse how the attitudes, skills and knowledge of medical student concerning eHealth and healthcare digitalization have shifted from 2016 to 2022 in connection with the development of the national healthcare information system architecture utilizing the Clinical Adoption Meta-Model framework.

Methods: The research population consisted of fifth-year medical students from one University in Finland during 2016, 2021 and 2022. A survey questionnaire was administered which comprised seven background questions and 16 statements measured on a five-point Likert scale assessing students' attitudes towards eHealth and their digital capabilities. The results were recategorized into a dichotomous scale and presented using frequencies and percentages. The statistical analysis employed a Pearson's chi-square test.

Results: The study involved 215 medical students (n = 45 in 2016, n = 106 in 2021, and n = 64 in 2022). Overall, the medical students displayed positive attitudes towards the use of digital applications in healthcare. Knowledge about the national health information exchange service has significantly improved over time. Despite positive changes in skills and attitudes among students, recent observations also indicate a more reserved stance towards healthcare digitalization.

Conclusions: There has been a positive shift in the digital competence and attitudes of medical students over the years, potentially influenced by the development of the national health information system architecture. Highlighting digital health topics and interdisciplinary teaching in basic medical education is essential to foster innovation and to ensure future doctors possess a high level of digital competence.

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Original Paper

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Authors' contributions

Paula Veikkolainen, Timo Tuovinen, Petri Kulmala, Erika Jarva, Jonna Juntunen, Annukka Tuomikoski, Merja Männistö, Teemu Pihlajasalo and Jarmo Reponen were responsible for the conception and design of the study as well as the acquisition and interpretation of the data. Paula Veikkolainen conducted the statistical analyses and drafted the tables and figures. Paula Veikkolainen wrote the original draft conceptualization. Timo Tuovinen, Petri Kulmala, Erika Jarva, Jonna Juntunen, Annukka Tuomikoski, Merja Männistö, Teemu Pihlajasalo and Jarmo Reponen reviewed and edited the manuscript. Teemu Pihlajasalo was responsible for the conception and design of the survey questions and the study as well as commenting on the manuscript. The final version of the manuscript was approved by all contributing authors.

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The Evolution of Medical Student Competencies and Attitudes in Digital Health between 2016-2022: A Comparative Cross-Sectional Study

Abstract

Background: Modern healthcare systems worldwide are facing challenges, and digitalization is viewed as a means to strengthen healthcare globally. As digitalization in healthcare demands adjustments in practices, policies, and workflows, assessing healthcare professionals' competencies is crucial for effective integration into their work environment.
Objective: The aim of this study was to analyse how the attitudes, skills and knowledge of medical student concerning eHealth and healthcare digitalization have shifted from 2016 to 2022 in connection with the development of the national healthcare information system architecture utilizing the Clinical Adoption Meta-Model framework.
Methods: The research population consisted of fifth-year medical students from one University in Finland during 2016, 2021 and 2022. A survey questionnaire was administered which comprised seven background questions and 16 statements measured on a five-point Likert scale assessing students' attitudes towards eHealth and their digital capabilities. The results were recategorized into a dichotomous scale and presented using frequencies and percentages. The statistical analysis employed a Pearson's chi-square test.
Results: The study involved 215 medical students (n = 45 in 2016, n = 106 in 2021, and n = 64 in 2022). Overall, the medical students displayed positive attitudes towards the use of digital applications in healthcare. Knowledge about the national health information exchange service has significantly improved over time. Despite positive changes in skills and attitudes among students, recent observations also indicate a more reserved stance towards healthcare digitalization.
Conclusions: There has been a positive shift in the digital competence and attitudes of medical students over the years, potentially influenced by the development of the national health information system architecture. Highlighting digital health topics and interdisciplinary teaching in basic medical education is essential to foster innovation and to ensure future doctors possess a high level of digital competence.

Keywords: eHealth, telemedicine, medical informatics, professional competence, medical education, medical students, digitalization

Introduction

Modern healthcare systems around the world are facing challenges due to the aging population, increasing prevalence of chronic diseases and other lifestyle-associated conditions [1,2]. At the same time, countries are grappling with shortages of the healthcare workforce, especially in remote and rural areas [3]. Different exposures to health risks create health inequalities between individuals with higher and lower education and income levels [4,5]. These factors put pressure on healthcare systems to shift their focus towards promoting health and preventing diseases through patient engagement and self-management.
Digital transformation is seen as an essential component and enabler to enhance the quality, accessibility, and affordability of health services [2,6]. In 2021, the World Health Organization (WHO) published the *Global strategy on digital health 2020-2025,* seeking to assist nations in

strengthening their healthcare systems through digitalization [7]. The European Union (EU) has named digital solutions as one of the key enablers to deliver health and care services more effectively to patients [8,9]. The COVID-19 pandemic (which began in 2020) and the resulting lockdowns accelerated the technological leap by forcing healthcare institutions worldwide to develop and implement digital strategies at an accelerated pace [10–13].

In 2022, Finland was ranked as the top country in the annual Digital Economy and Society Index (DESI) report which monitors the digital progress of the European Union Member States [14]. Accordingly, Finland has a long history of enforcing healthcare digitalization [15,16]. One example of this development is the introduction and implementation of the Finnish nationwide, centralized shared electronic data system service, called the Kanta Services, which comprises several service entities such as an electronic patient portal, prescription database and patient data repository. The implementation of these services has taken place in several stages throughout the 2010s [17–19].

In Finland, the key competence requirements for a graduating doctor have been established at a national level [20]. These requirements are based on international literature, including the UK's Generic professional capabilities framework and the International Association for Medical Education (AMEE) guidelines [21–23]. The basic education for medical professionals in Finland consists of two years of pre-clinical studies followed by four years of clinical training. In the European Union, the profession of the medical doctor is recognized as a qualification in all member states on the basis of harmonized minimum training requirements [24].

As digitalization in healthcare demands adjustments in practices, policies, and workflows, assessing healthcare professionals' competencies is crucial for effective integration into their work environment [25]. According to current literature, medical students globally have positive attitudes towards learning about eHealth and healthcare digitalization and consider the introduction of digital health topics into the medical curricula to be important [26–34]. However, more reserved perceptions towards healthcare digitalization have also been reported among students [35]. Efforts have also been made to modernize basic medical education in Finland; an example of this is the national MEDigi project (2018–2021) funded by the Finnish Ministry of Education and Culture. In addition to digitizing the teaching of medicine and dentistry, the project aimed to ensure a high level of competence in the use of electronic healthcare tools among medical students and to establish national eHealth competence themes [36,37].

In our previous study, we aimed to compare the attitudes of medical and nursing students towards eHealth and healthcare digitalization. Based on the study results, the differences between the two student groups were small, and overall, the students' attitudes towards healthcare digitalization were positive [33]. Now, we seek to deepen our understanding of the changes in medical students' attitudes, skills and knowledge regarding digitalization in relation to the underlying development of the national healthcare information system architecture. For this purpose, we utilised the Clinical Adoption Meta-Model (CAMM) framework. This framework is developed to describe the health information system adoption over time, and it incorporates four dimensions: availability, use, behaviour changes, and outcome changes [38]. In this study, the aim is to focus on the third dimension of the model, namely, to describe the behaviour changes (attitudes and competencies) of medical students in connection with the development of the national healthcare information system architecture over time.

Materials and methods

Ethical statement

The research was conducted in accordance with the instructions of the Finnish Advisory Board

on Research Integrity [39], and in compliance with EU data protection regulations [40] as well as the established research practices of the University of Oulu and the Faculty of Medicine. Therefore, no approval from the ethics committee was required. Full consideration was given to matters related to data protection in accordance with the ethical principles applicable to research subjects. Participation in the study was voluntary, and students were asked for their consent to collect and use data for the purpose of the study. The students were informed of the purpose of the study, their right to withdraw and prohibit the use of their data at any time. No incentives were offered for participation.

Study design

The study population for this comparative cross-sectional study consisted of a non-random purposive sample of fifth-year medical students at the University of Oulu who participated in a compulsory one-day eHealth course held in spring 2016, 2021 and 2022. The students were invited to participate in the study via email in 2016, and through the course's Moodle environment in 2021 and 2022. The aim of this one-day course was to provide essential knowledge on eHealth and its applications from the perspective of healthcare professionals. There were 105, 144 and 154 medical students who enrolled on the courses in 2016, 2021 and 2022, respectively.

Study questionnaire

After completing the eHealth course, an online survey was conducted on the students' perceptions of eHealth using a Webropol survey tool. The survey was compiled in 2016, and it was developed based on literature and expert reviews [41]. The survey was piloted prior to its use. The pilot group consisted of two fifth-year medical students and two medical teachers who also taught issues related to digitalization.

The Finnish-language survey questionnaire consisted of 16 statements measured on a five-point Likert scale ('Fully disagree' to 'Fully agree'), surveying students' attitudes to digital health and their digital competencies. The survey used in 2021 and 2022 was adapted from the 2016 survey by changing the term "medical doctor" to "healthcare professional" as nursing students also participated in the one-day course in 2021 and 2022. An English translation of the latter questionnaire is presented in Appendix A. The statements were related to five themes concerning the digitalization of healthcare and eHealth: 1) the usage of patient-generated information and the role of digital applications in patient care; 2) health information systems; 3) the digitalization of the working environment; 4) the changing role of patients and professionals; and 5) the culture of experimentation and readiness to participate in innovation activities.

Data analysis

The five-point Likert-scale responses 'Fully agree' and 'Somewhat agree' were combined to form the category 'Agree'. Similarly, the responses 'Fully disagree, 'Somewhat disagree' and 'Neither agree or disagree' were combined to form the category 'Disagree'. The data analysis was conducted using a Pearson's chi-square test to examine relationships between the medical student's attitudes and competences in 2016, 2021 and 2022. A P-value less than .05 was considered statistically significant [42].

Results

Demographic characteristics of the study population

The study included a total of 215 medical students (n=45 in 2016, n=106 in 2021, and n=64 in 2022), with an overall response rate of 53% (43% in 2016, 74% in 2021, and 42% in 2022). Details regarding gender distribution and age distribution are presented in Table 1.

Table 1. Demographic characteristics of the study population (n=215) including gender distribution and age distribution by decade of birth.

Characteristics	Medical students in 2016, n (%)	Medical students in 2021, n (%)	Medical students in 2022, n (%)
Gender distribution			
Female	27 (60)	56 (53)	34 (53)
Male	18 (40)	50 (47)	27 (42)
Other			3 (5)
Age distribution (birth decade)			
1960	3 (7)		
1970	3 (7)		1 (1.5)
1980	20 (44)	13 (12)	7 (11)
1990	19 (42)	93 (88)	55 (86)
2000			1 (1.5)

The average working experience in healthcare sector was 1.1 years (± 1.3 SD) in 2021 and 0.9 years (± 1.1 SD) in 2022. In the 2016 survey 96% of the students had worked as assistants to medical doctors. The work experience of the students in a field corresponding to their prior education was on average 1.1 years (± 2.5 SD) in 2021 and 0.9 years (2.1 SD) in 2022.

The usage of patient-generated information and the role of applications in patient care

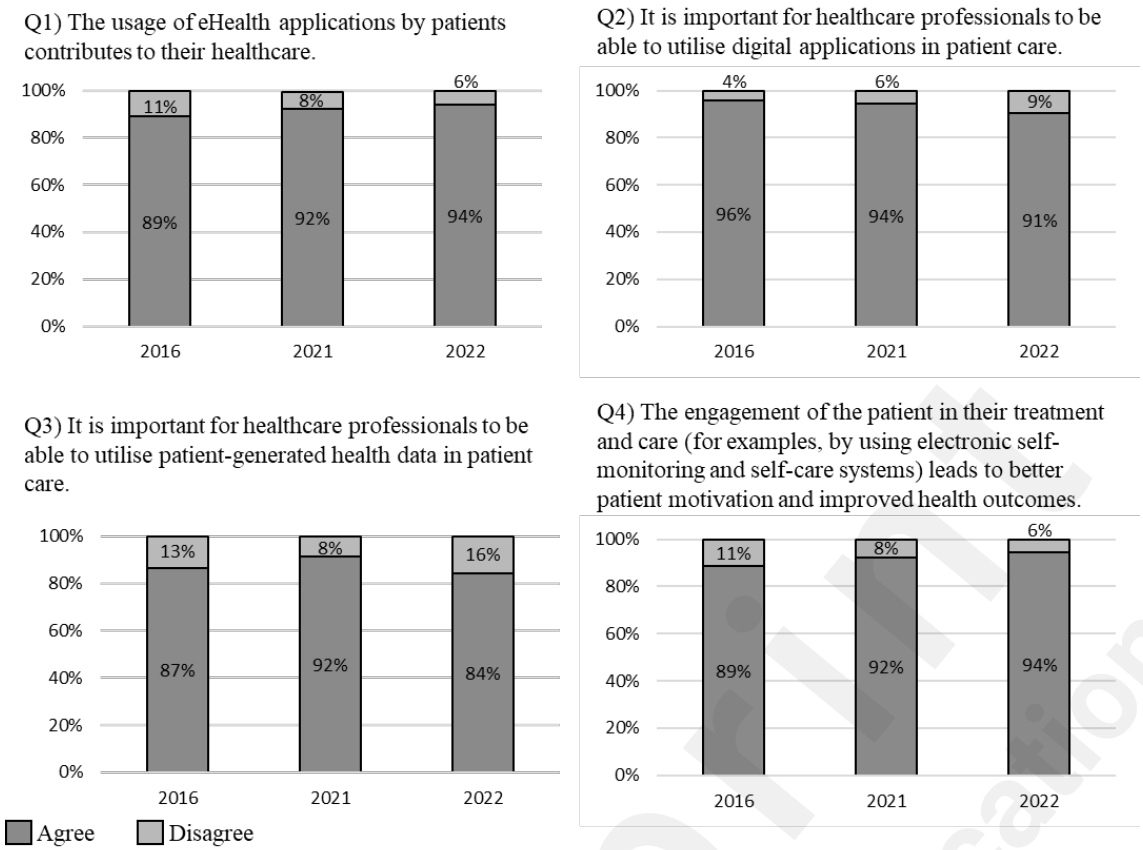

Figure *1*. The usage of patient-generated information and the role of applications in patient care. A statistical analysis was performed using a chi-square test.

Overall, there were not any major changes in attitudes towards the usage of patient-generated information and the role of digital applications in patient care among medical students between 2016, 2021 and 2022 (Figure 1). The participating students had positive attitudes towards this topic and believed that the use of digital applications contributes to the health and motivation of patients. At the 2016, 2021 and 2022 checkpoints, the students considered it important for healthcare professionals to be proficient in using digital applications in their work.

Health information systems

There was a significant improvement in the students' self-evaluated knowledge of the information contained in the national patient portal (My Kanta Pages) (Figure 2). The proportion of students who agreed with this assertion increased by 35 percentage points over the 5-year period from 2016 to 2021, and this growing trend continued in 2022.

However, there were no significant differences in how the participating students estimated their skills in the use electronic medical records over the time period. If anything, the students perceived their skill set to be weaker in 2022 compared to both 2016 and 2021, although this difference was not statistically significant.

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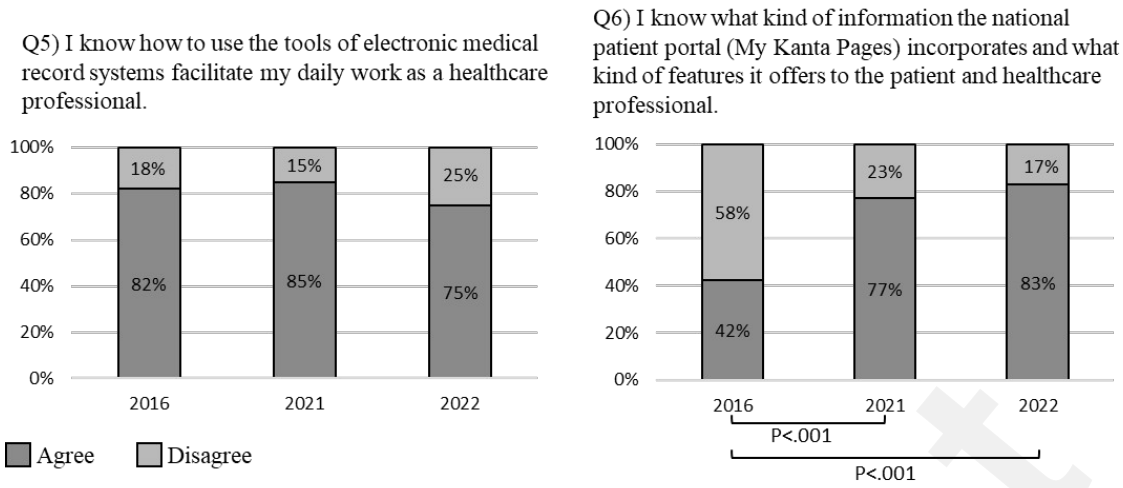

Figure 2. Health information systems. A statistical analysis was performed using a chi-square test.

The digitalization of the working environment

There was a statistically significant difference in students' perceptions of how digitalization would affect their working lives in the coming years, between 2021 and 2022. In 2021, only 7% of the students disagreed with the claim "The digitalization of healthcare induces significant changes to the daily routines of healthcare professionals" (as well as in 2016), whereas in 2022, this number rose to 17%.

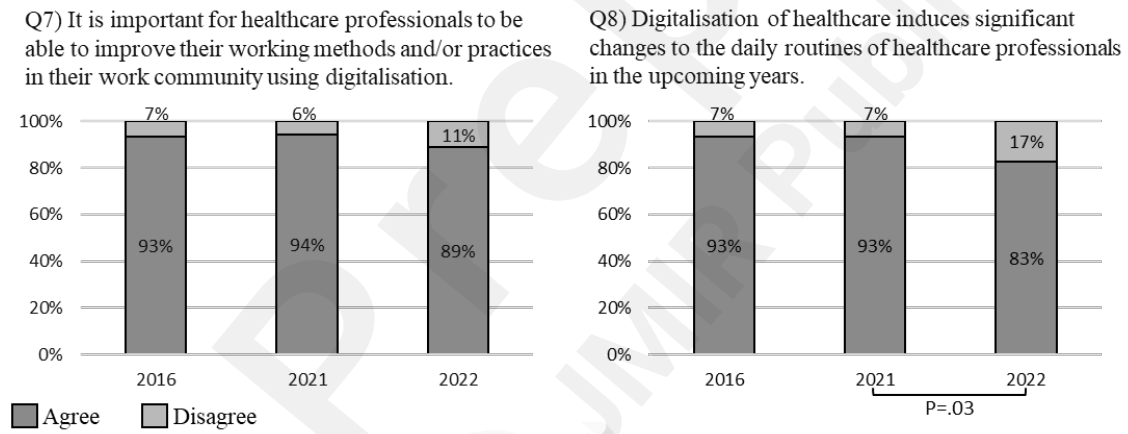

Figure 3. The digitalization of the working environment. A statistical analysis was performed using a chi-square test.

The changing role of patients and professionals

Between 2016 and 2021, the participating students' attitudes about the roles of patients and professionals changed (Figure 4). In 2021, the medical students perceived increased patient participation in managing their health information and noted a levelling of the hierarchy between patients and professionals compared to students in 2016. However, there was not a statistically significant difference in attitudes between 2016 and 2022, nor between 2021 and 2022. Additionally, the students' attitudes towards the effects of digitalization on health promotion became more positive from 2016 to 2021 but declined again by the 2022 checkpoint.

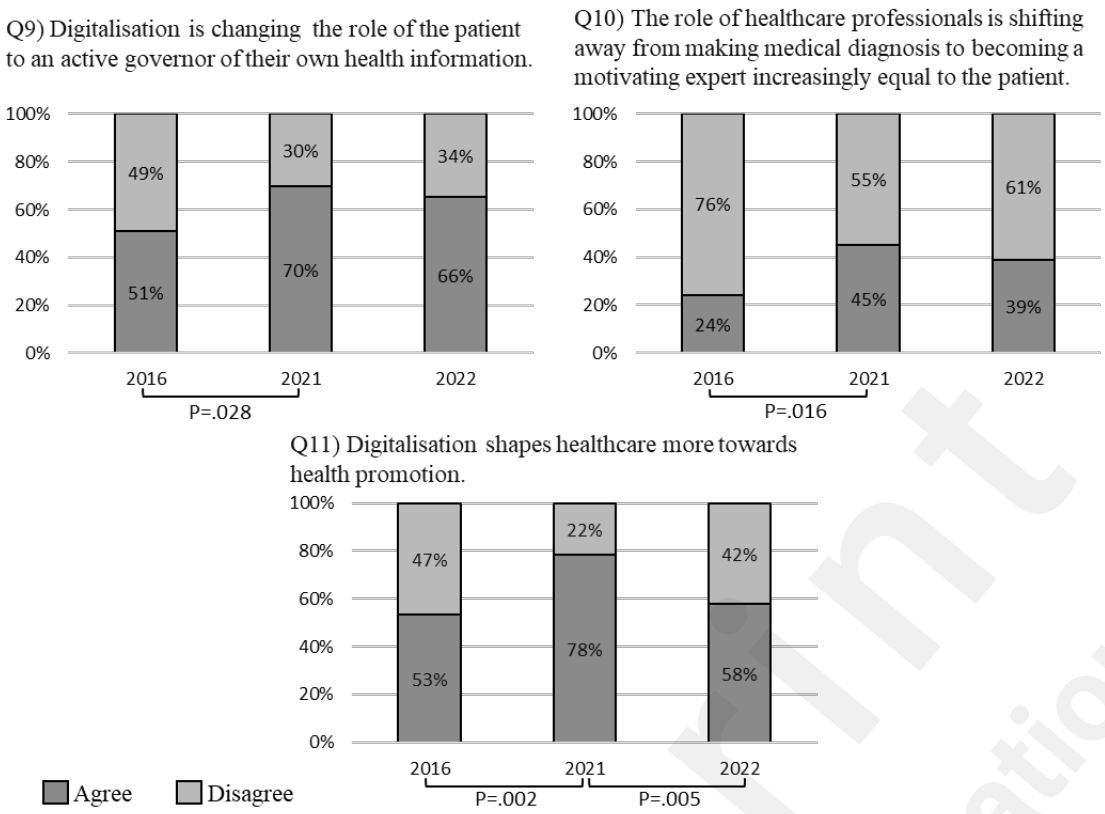

Figure 4. The changing role of patients and professionals. A statistical analysis was performed using a chi-square test.

The culture of experimentation and readiness to participate in innovation activities

The participating students considered the inclusion of digital health in basic medical education to be important in 2016, 2021 and 2022, with no significant changes in attitudes observed across the three checkpoints (Figure 5). In addition, alternative career options, such as product development, had become increasingly appealing to medical students over time. The percentage of students who viewed product development as a potential career path more than doubled between 2016 and 2021. This percentage remained relatively stable in the 2022 questionnaire compared to the previous year's results.

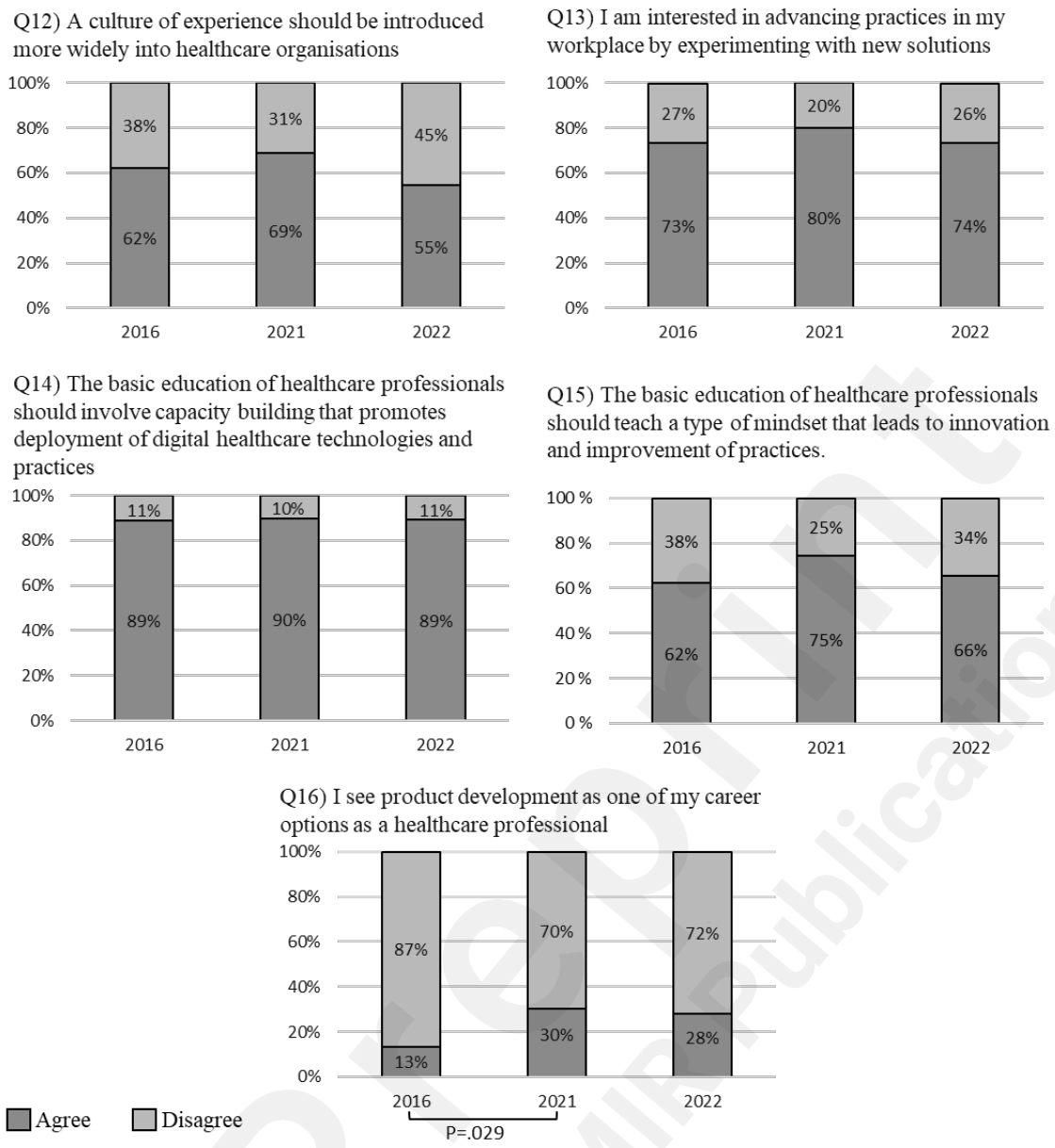

Figure 5. The culture of experimentation and readiness to participate in innovation activities. A statistical analysis was performed using a chi-square test.

Discussion

Overall, we observed a positive shift in the participating medical students' attitudes and an improvement in their digital competences between 2016 and 2021. This coincides with advancements in the national health information system providing an excellent opportunity to assess the outcomes from the CAMM framework viewpoint. Interestingly, we observed that the changes in attitudes were not consistently linear; while there was a positive trend overall, the 2022 results showed signs of stagnation or decline, with the exception of the students' increasing knowledge of the national patient portal.

To our knowledge, there has been only one umbrella review describing healthcare providers' attitudes to patient portals using CAMM [43]. This study primary focused on the adoption of patient portals revealing predominantly reserved attitudes and concerns among professionals. Our study contributes to this by extensively mapping the attitudes and digital competences of future healthcare professionals, reflecting potential changes connected to the advancements in the national health information system architecture across three different time points.

In our study, medical students perceived the use of digital applications and patient-generated data in patient care as a positive factor: there were no statistically significant differences in the participating students' attitudes between 2016, 2021 and 2022 (see Fig. 1). From a system adoption point of view, this finding suggests that the widespread use of digital applications had already prompted students to recognize their importance as early as 2016. European Union legislation has emphasized the role of medical and health digital applications as a part of patient empowerment and has recognized potential risk aspects [1,44]. Both the WHO and the European Commission have participated in establishing the European mHealth Knowledge and Innovation Hub as part of the Horizon 2020 project [45]. The initiative aims to support the integration of mHealth services into the national health systems of European countries.

Our results indicate a significant improvement in medical students' knowledge of the national patient portal since 2016 (see Fig. 2, Q6). We believe that this development may be linked to the introduction and implementation of new national health information exchange services in the 2010s and beyond. For example, the implementation of the national patient data repository in public healthcare in Finland was only completed in late 2015, less than year before our first data checkpoint [16,19]. Similar nationwide systems for the exchange of health information between patients and professionals can be found in several countries [46–50], but studies on students' competences in the use of these systems are scarce in the literature. Additionally, we discovered that students in 2022 rated their ability to use electronic patient records systems slightly lower than students both in 2021 and 2016. Although this finding was not statistically significant, we know that requirements for recording patient data have become more demanding, and the functionalities of the systems have increased [51]. These trends may have influenced the students' perceptions in 2022.

Prior research indicates that medical students have concerns regarding the impact of digitalization on the patient-doctor relationship [28,35]. Our study reveals a shift in the attitude environment related to the roles of patient and professionals. We discovered a statistically significant difference between the year 2016 and 2021 in the participating students' attitudes towards patients' roles in managing their health information and collaborating with professionals. Additionally, students in 2021 recognized the role of digitalization in shaping healthcare towards health promotion. These findings align with both national and European Union health strategies which emphasize electronic services to support the active role of citizens in maintaining their own well-being [1,52]. In Finland, the national health exchange services were complemented by a personal health record repository service (Kanta Personal Health Record or Kanta PHR), which entered its first-phase production in 2018 [19]. The service allows citizens to input, store and share their well-being data with professionals. At the EU level, the EU is establishing a European Health Data Space ecosystem aiming to empower individuals of member states with control over their health data [53].

Overall, we saw slightly more reserved attitudes towards eHealth and healthcare digitalization in 2022 compared to 2021. The assertion 'The digitalization of healthcare induces significant changes to the daily routines of healthcare professionals' was significantly less supported in 2022 compared to 2021 (see Fig. 3, Q9). This trend suggests that electronic health services and tools have become fully integrated into the healthcare system. It may even indicate that, from the students' perspective, digitalization has reached its peak in healthcare. This shift could be linked to the advancements in eHealth education in the basic medical training in Finland, such as the completion of the national MEDigi project in 2021 and the introduction of its eHealth competence areas to students as early as 2020. [36,37].

Another noteworthy discovery was the significant in the percentage of students who agreed with the claim "Digitalization shapes healthcare more towards health promotion" between 2021 and 2022 following a statistically significant shift towards a more positive stance between

2016 and 2021 (see Fig 4, Q11). This change in attitudes could be partly linked to the "care debt" and prolonged waiting times for treatment which emerged during the global health emergency caused by the COVID-19 pandemic in 2020–2023 [54,55]. It is also possible that after over two years remote and blended education, students in 2022 may be exhibiting signs of digital fatigue. As a result, the surge in digitalization driven by the COVID-19 pandemic may had started to decline by 2022. Nevertheless, these trends require further research to fully comprehend the underlying causes behind the phenomenon. The more reserved attitudes of the participating students and their somewhat lower self-assessed skills suggest the necessity for an increased focus on digital training for future healthcare professionals. This is crucial to ensure their competences align with the broad health strategies in Europe and on a global scale.

The medical students who participated in this study in 2016, 2021 and 2022 were aligned in their belief that the basic education of healthcare professionals should include capacity building promoting the deployment of digital health solutions (see Fig 5, Q14). This consensus resonates with findings from previous studies [26–34]. The students' attitudes shifted positively towards alternative career paths such as product development (see Fig 5, Q16). This change was statistically significant between 2016 and 2021: in 2016 only 13% of students agreed with this claim, whereas almost a third of the students agreed with it in 2021. Although the difference between 2016 and 2022 was not statistically significant, the trend was consistent with percentages of 13% and 28%, respectively. This is an important finding as end-user involvement is considered a critical success factor in information technology projects [56–59]. A Finnish study revealed that younger physicians were more eager to participate in health information system development compared to their older counterparts [60]. Additionally, research indicates that interdisciplinary collaborations between healthcare and engineering professionals can foster innovation and new practices underscoring the importance of interprofessional education [61,62]. However, introducing eHealth topics and innovation activities into medical curricula has proven to be a challenging in practice due to crowded curricula designs and competing interests [29,63–65].

Strengths and limitations

Our overall response rate was 53%. Our study sample was collected from one of the five Finnish medical universities at three different time points. The results are likely to be applicable to other Finnish medical faculties given the similar surrounding healthcare system and relatively homogeneous education system [66]. Furthermore, these findings may also have relevance to other countries, particularly those with similar healthcare systems, healthcare information system architecture and medical curriculum design. However, confirming this would necessitate further research.

There are also several limitations to this study. While cross-sectional studies are useful for examining associations, causal relationships cannot be established, which should be considered when interpreting the findings. We relied on self-assessment to evaluate competences in this study, which means we were unable to measure absolute changes in skills and knowledge. Because of minor variations in the collection of demographic characteristics among the study population, a statistical comparison of the students' demographic characteristics could not be conducted. Furthermore, the dichotomization of variables potentially hindering their reflection of real-world situations.

Conclusions

There has been a shift in digital competence and attitudes of medical students over the years, potentially influenced by the development of national health information system architecture.

However, this change has not followed a completely linear trajectory, and students' attitudes towards the role of digitalization in healthcare have become somewhat more reserved over time.
Highlighting digital health topics and interdisciplinary teaching in basic medical education is essential to foster innovation and to ensure future doctors possess a high level of digital competence.

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Conflicts of interest

The employer of Paula Veikkolainen, Petri Kulmala, Timo Tuovinen and Jarmo Reponen received support for salaries from the MEDigi project funded by Finnish Ministry of Education and Culture [MEDigi OKM/270/523/2017]. Otherwise, the authors declare no other known competing financial interests or personal relationships that may have influenced the work reported in this paper.

Abbreviations

AMEE: the International Association for Medical Education
CAMM: Clinical Adoption Meta-Model
COVID-19: coronavirus disease 2019
DESI: Digital Economy and Society Index
EU = European Union
ICT = information and communications technology
WHO = World Health Organization

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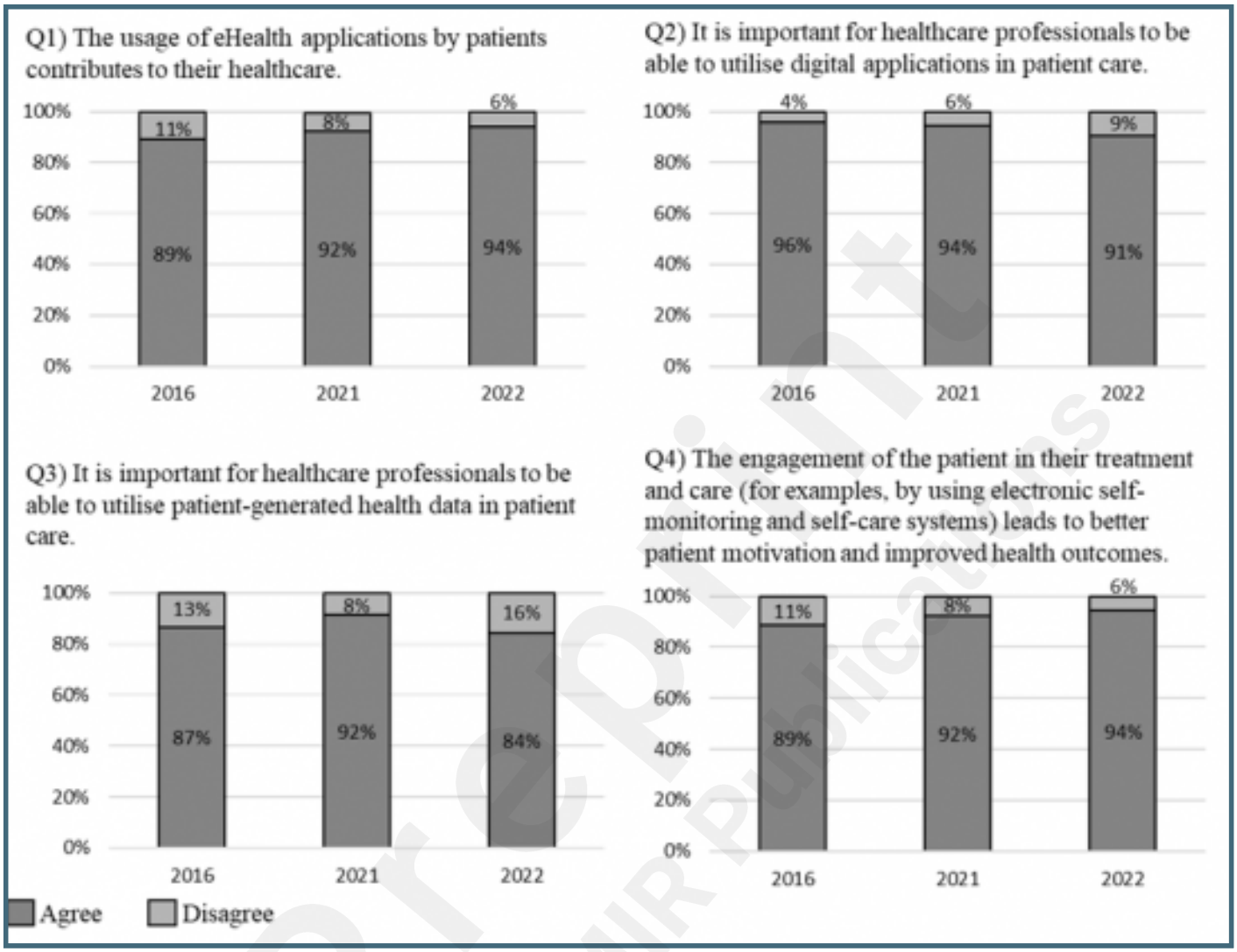
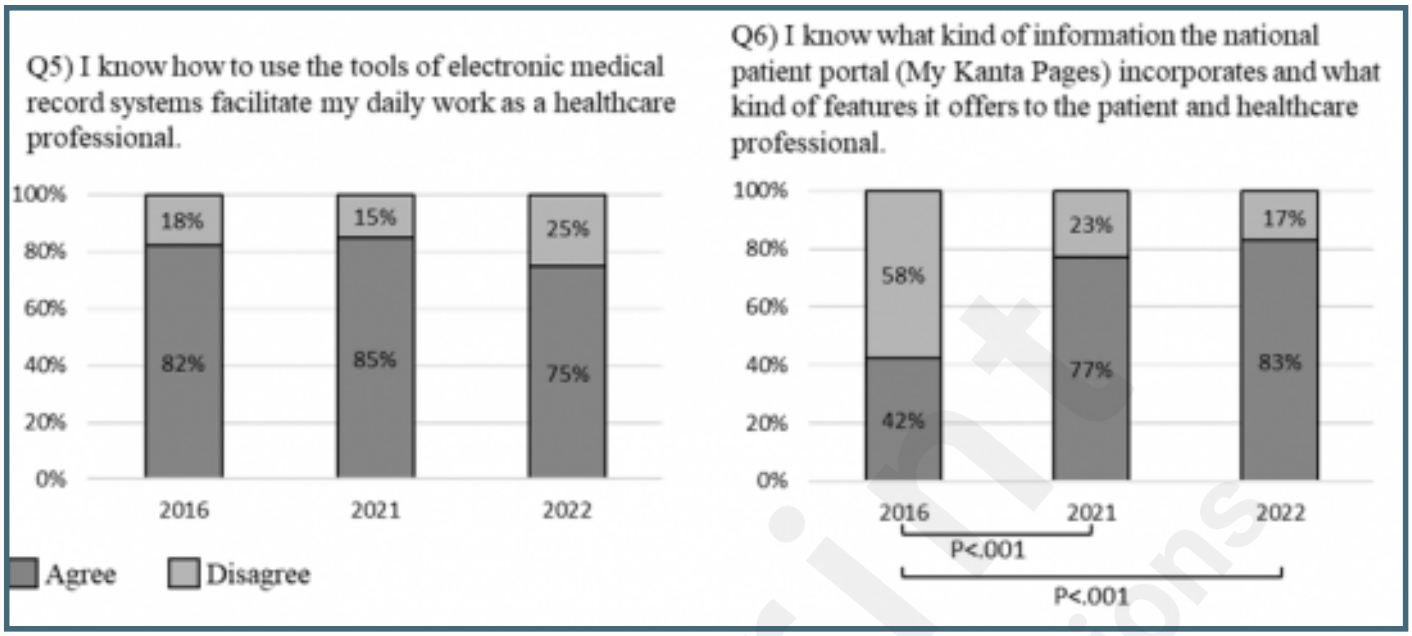
The usage of patient-generated information and the role of applications in patient care. A statistical analysis was performed using a chi-square test.



Health information systems. A statistical analysis was performed using a chi-square test.



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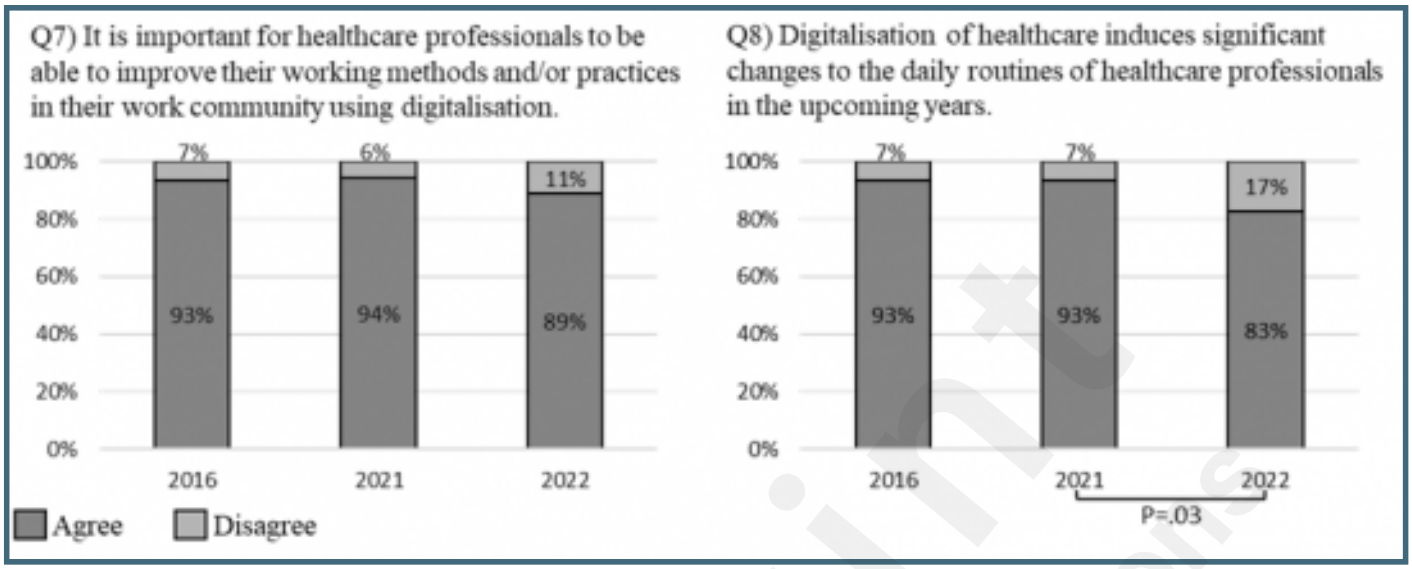
The digitalization of the working environment. A statistical analysis was performed using a chi-square test.



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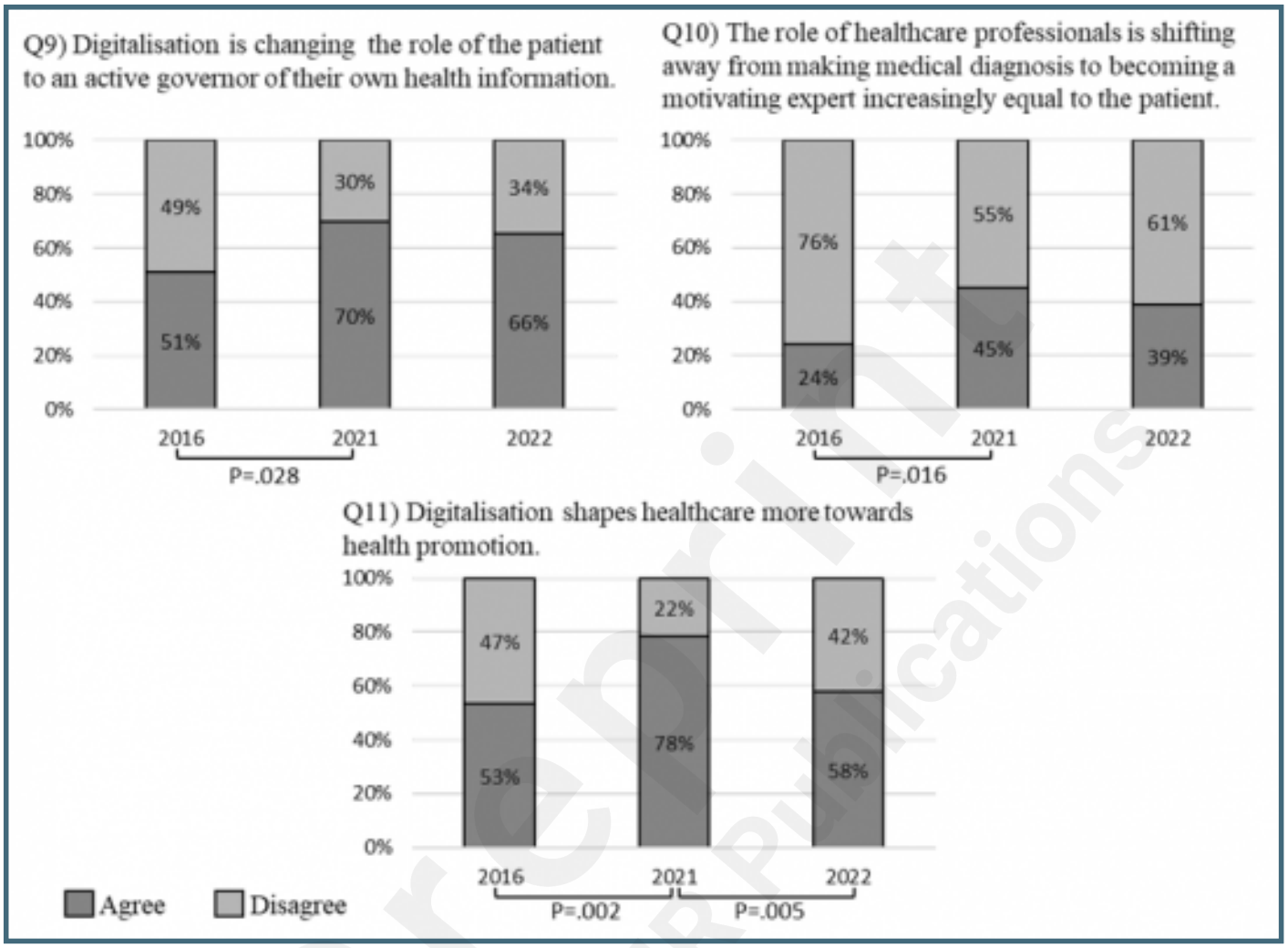
The changing role of patients and professionals. A statistical analysis was performed using a chi-square test.



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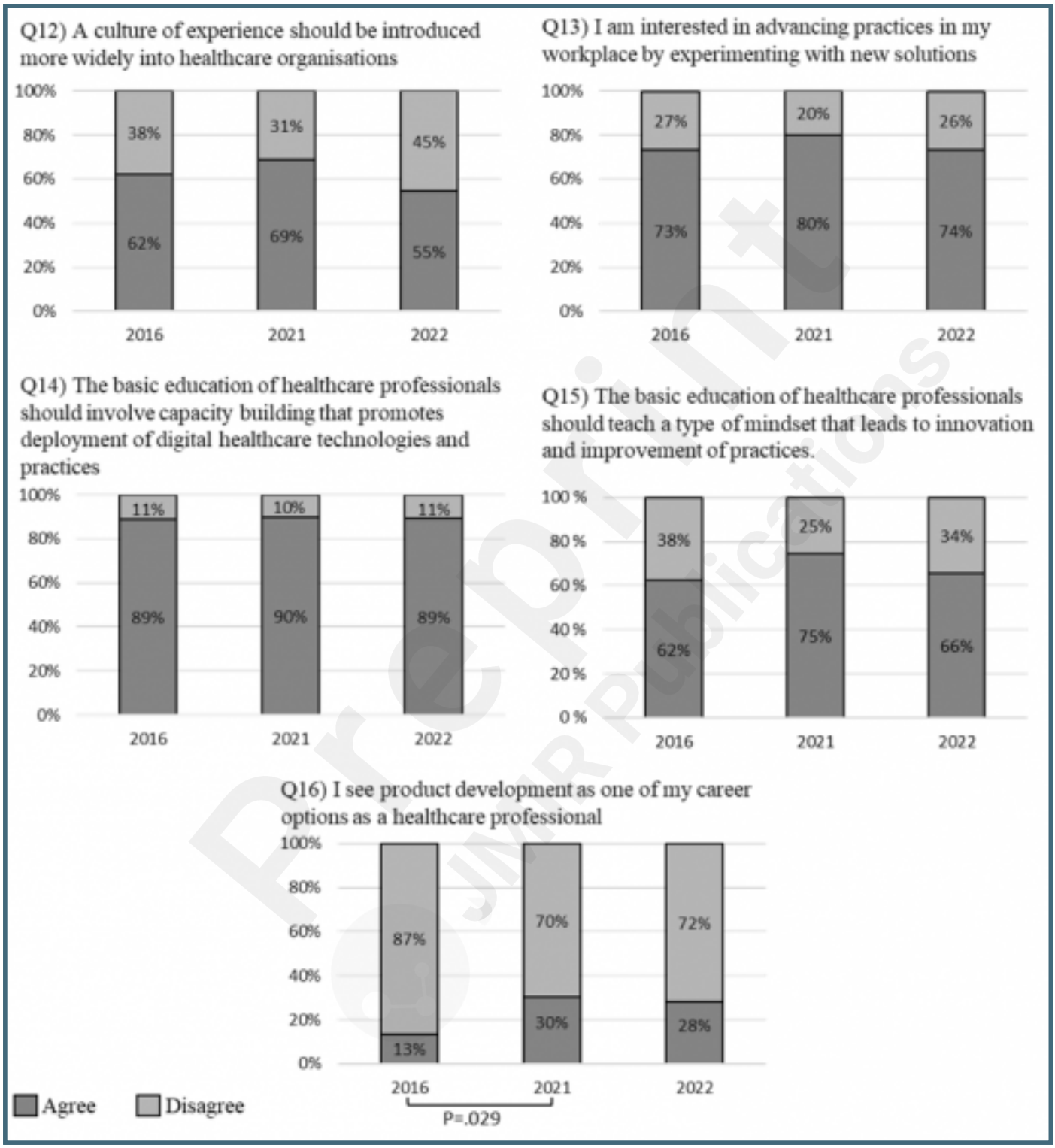
The culture of experimentation and readiness to participate in innovation activities. A statistical analysis was performed using a chi-square test.