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Pharmacy Education: Preparing Pharmacists for Global Challenges in the Digital Age

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ABSTRACT

This study aims to examine the development of pharmacy education in the digital era, as well as to prepare pharmacists to face global challenges. The method used is the Systematic Literature Review (SLR), which is carried out by collecting, evaluating, and synthesizing previous research results comprehensively. The research process includes identifying literature through academic databases such as Scopus, PubMed, Google Scholar, and ScienceDirect, selecting studies based on inclusion and exclusion criteria, extracting data related to objectives, methods, results, and conclusions, synthesizing findings, and reporting research results. The results of the study indicate that pharmacy education needs to transform to prepare competent pharmacists in the digital era. Integration of technology into the curriculum such as e-learning, blended learning, augmented reality (AR), and virtual reality (VR) provides a more flexible learning experience. In addition, mastery of technology such as big data, artificial intelligence (AI), and pharmacy information systems is essential to support evidence-based decision making and efficiency of health services. The challenges faced include limited infrastructure, resistance to change, and the gap between the competencies taught and the digital skills needed in the world of work. Therefore, curriculum updates and training for pharmacists who are already working are very necessary to ensure pharmacists are prepared to face an increasingly digitalized profession.

INTRODUCTION

The digital era has brought major changes to various aspects of life, especially in the health and pharmaceutical sectors. Digital technology changes the way we interact with the health system, increases service efficiency, and provides wider access to the public to obtain medical and pharmaceutical services (Rambe, A. et al. 2024). One of the biggest innovations in the health sector is telemedicine and telepharmacy. Telemedicine allows patients to consult with medical personnel via video calls or other digital platforms, while telepharmacy allows pharmacists to provide remote pharmacy services, including drug consultations and patient therapy monitoring. Both of these technologies open up wider access for patients, especially those in remote areas (Wijaya, H., et al.

2023). On the other hand, the use of Electronic Medical Records (EMR) and health information systems further facilitates collaboration between medical professionals. Patient data stored in digital format can be accessed in real-time, allowing doctors and pharmacists to provide more coordinated and evidence-based care. In the pharmaceutical sector, this information system also helps pharmacists manage prescriptions, monitor drug interactions, and provide more accurate treatment recommendations. In addition, artificial intelligence (AI) and big data technologies play an important role in medical decision-making. AI can help pharmacists formulate more personalized therapies and predict dangerous drug interactions. The use of big data allows pharmacists to analyze health trends and provide more appropriate treatment recommendations (Daud, KR, et al. 2024).

Another innovation is the use of Augmented Reality (AR) and Virtual Reality (VR) in pharmacy education. This technology allows pharmacy students to practice laboratory skills or interact with patients in virtual simulations, so they can gain more practical and realistic experience without direct risk. On the other hand, digital-based pharmacy applications are increasingly developing, allowing pharmacists to administer medications, monitor patient therapy, and provide treatment-related information more efficiently through mobile or cloud-based platforms (Metaverse, NIE 2022).

However, with the advancement of technology, the issue of data security has become very important. With more and more medical data being stored digitally, pharmacists and other healthcare professionals need to have the skills to protect patient information in accordance with applicable regulations, such as GDPR or HIPAA. Data security is a factor that cannot be ignored to ensure patient privacy is maintained. In addition, the digital era has also changed the role of pharmacists in the health ecosystem, from providing medication and direct consultations, to being involved in broader health systems such as telemedicine and data-based therapy management (Ayu, RJID, & Lazuardi, L. 2023). Therefore, pharmacists must master the latest technology and develop relevant digital skills to keep up with the development of their profession. Collaboration between pharmacists, other healthcare professionals, and the technology industry is increasingly important in facing digital challenges. Health technology start-ups and pharmacy software companies are working with hospitals and pharmacies to develop innovative solutions that improve efficiency and quality of service. To take full advantage of the digital era, pharmacy education and training for pharmacists who are already working must continue to adapt to technological developments, so that pharmacists can meet the demands of their profession in an increasingly digitalized world. The development of information and communication technology has created new challenges as well as opportunities for health professionals, especially pharmacists. In the midst of the industrial revolution 4.0, the role of pharmacists is no longer limited to drug distribution, but also includes aspects of digital technology-based health services, telepharmacy, and health data management. This transformation requires pharmacy education to be able to prepare prospective pharmacists with competencies that are relevant and adaptive to global change. Pharmacy education must be able to integrate traditional pharmacy knowledge with the use of digital technology, such as artificial intelligence, big data, and digital health applications. Therefore, an innovative curriculum is needed that is responsive to the dynamics of the times (Wijaya, H. et al. . (2023).

In addition, global challenges such as mobility of health workers between countries, changes in international regulations, and demands for faster and more accurate pharmaceutical services also affect pharmacist competency standards. In the context of

globalization, the mobility of health workers, including pharmacists, is increasing, with many pharmacists working abroad or working on international projects. This requires a broader understanding of the regulations and standards of health services that apply in various countries. Pharmacists must have in-depth knowledge of international regulations related to pharmacy, such as regulations on drug management, pharmaceutical distribution, and reporting of drug side effects that vary between countries (Aji, PT, & Ns, MK 2020). Therefore, pharmacists not only need to understand national laws and regulations, but must also be able to adapt to evolving global health policies. Changes in international regulations, such as regulations related to drug safety, pharmaceutical distribution, and ethical standards in health services, are challenges that pharmacists must face. The impact of these global policy changes forces pharmacists to continue to update their knowledge of international standards that can affect their pharmacy practice. For example, regulations regarding the distribution of medicines in countries with stricter standards can affect the process of obtaining and providing medicines, as well as ensuring that the medicines used are safe and effective (Nabil, ME 2024).

In addition, the demand for faster and more accurate pharmaceutical services is increasing, along with the increasing need for easier and more instant access to health care. Patients now expect fast, precise, and efficient services, both in administering drugs and in pharmaceutical consultations. In facing these demands, pharmacists must master digital skills to be able to access drug information in real time, interact with patients through digital platforms, and use technological devices to provide data-based treatment recommendations. Understanding digital literacy and the ability to analyze patient data effectively are key to meeting these expectations. With advances in technology, today's pharmacists are also required to master skills in data analysis, including the use of big data in managing drug therapy. The ability to interpret big data and draw accurate conclusions about patient therapy is becoming increasingly important. For example, data analysis can help pharmacists monitor drug use, identify potential drug interactions, or design more personalized and appropriate therapy for the patient's condition (Effendi, Z. 2021).

In addition, pharmacists also need to have a broader understanding of global health policies, such as regulations related to drug access, evidence-based medicine, and monitoring of drug side effects at the international level. The ability to understand these health policies will enable pharmacists to provide services that meet not only national standards, but also international standards (Hartayu, TS, et al. 2020). Sanata Dharma University Press. Therefore, pharmacy education and continuing training must continue to develop pharmacists' competencies so that they can face these global challenges, as well as meet the expectations of society and the profession in the ever-evolving digital era. Therefore, this study aims to identify global challenges faced by pharmacists in the digital era, analyze the readiness of pharmacy education in preparing pharmacists who are adaptive to technological changes, and formulate strategies for strengthening the curriculum and developing digital competencies for prospective pharmacists. Thus, this study is expected to provide a comprehensive picture of the efforts needed to improve the quality of pharmacy education to make it more relevant to the needs of today's workforce.The benefits of this research are to contribute to the development of a pharmacy education curriculum that is more responsive to global needs and to be a reference for pharmacy education institutions in designing digital technology-based learning programs. In addition, this research is also expected to improve the competence

of pharmacy graduates to be better prepared to face the demands of a dynamic and high-tech work world.

METHODOLOGY

This study uses the Systematic Literature Review (SLR) method to review and analyze various literatures relevant to the topic of pharmacy education in the digital era. SLR is a structured and systematic research method in collecting, evaluating, and synthesizing previous research results comprehensively.

The SLR stages in this research include:

Literature Identification: Using academic databases such as Scopus, PubMed, Google Scholar, and ScienceDirect to collect relevant scientific articles, proceedings, and publications.

Study Selection: Conducting selection based on inclusion and exclusion criteria, such as relevance to the topic, year of publication (at least the last 5 years), and type of document (indexed journal article, international proceedings, or research report).

Data Extraction: Collecting data from selected studies, covering research objectives, methods, results, and conclusions related to pharmacy education and digitalization.

Synthesis of Findings: Analyzing data thematically to identify trends, challenges, and solutions in pharmacy education in the digital era.

Reporting Results: Compiling a structured report based on the results of literature synthesis, including conclusions and strategic recommendations for the development of pharmacy education.

This method was chosen because it is able to provide an in-depth and accurate picture of the development of pharmacy education in the digital era based on empirical evidence from various previous studies.
(Eden, BKS, et al. 2024).

RESULTS AND DISCUSSION

Readiness of Pharmacy Education in Facing the Digital Era

Integration of technology into the pharmacy education curriculum is an important step in preparing pharmacists who are ready to face the digital era. In this era, the use of technology in learning is increasingly needed to increase flexibility and accessibility. One form of technology integration is the application of e-learning and blended learning which allows pharmacy students to learn online or face-to-face (Tjandrawinata, RR (2024). In addition, simulation technologies such as augmented reality (AR) and virtual reality (VR) are also used to train laboratory skills and interaction with patients virtually, so that students can gain practical experience without having to be in a physical laboratory. In addition to learning technology, the use of big data and artificial intelligence (AI) is also important in pharmacy education. Students need to be equipped with health data analysis skills for evidence-based decision making. In addition, AI can also be used in more personalized and efficient drug compounding. Not only that, the development of a pharmaceutical information system also needs to be part of the curriculum, such as drug information management and telepharmacy for remote consultations.

Along with the development of technology, digital literacy and data security are aspects that cannot be ignored. Pharmacy students need to have digital literacy skills to be able to use technology wisely and safely, and understand regulations related to patient data privacy and security, such as GDPR and HIPAA. In addition, collaboration with the

health technology industry is also important in improving graduate readiness. Through collaboration with start-ups and participation in hackathons, students can be involved in the development of innovative digital solutions. To keep the curriculum relevant, an adaptive and flexible approach must be applied. One of them is project-based learning that encourages students to work on real digital projects. The curriculum also needs to provide learning modules that can be updated according to the latest technological developments. With comprehensive technology integration in the curriculum, pharmacy education graduates will be better prepared to face professional challenges in the digital era, while being able to utilize technological innovations to improve health services (Yunus, M., et al. 2023).

In facing the digital era, pharmacy education faces various challenges and obstacles that are quite complex. One of the main obstacles is the limited technological infrastructure in many educational institutions. Not all pharmacy colleges have access to sophisticated devices such as virtual reality (VR), augmented reality (AR), or digital simulation laboratories, resulting in a gap in the quality of education between institutions that have complete facilities and those that do not. In addition, many pharmacy educators still have difficulty adapting to the latest technology. Skills in using digital learning platforms or technology-based pharmacy applications are still limited, so the learning process is less than optimal. The high cost of implementing technology is also a major obstacle. Investment in purchasing devices, training teaching staff, and maintaining technology requires a large budget, making it a challenge especially for universities with limited funds. The inequality of access to technology in the regions also worsens this situation. Many students in remote areas do not have fast internet access or adequate digital devices, which makes them lag behind in technology-based learning compared to students in urban areas (Nasruddin, SP, et al. 2024).

In addition, resistance to change is also an obstacle. Some educators and students still prefer conventional methods and are reluctant to switch to a digital approach. This can hinder the adoption of technology that should be able to improve the effectiveness of learning. Data security and privacy issues must also be a serious concern, especially in the use of digital platforms and health applications. Lack of understanding of security standards such as GDPR and HIPAA has the potential to threaten patient data privacy. Finally, the curriculum that is not fully ready to adapt to technological developments is also a challenge. Many pharmacy education curricula are still conventional and do not include learning materials that are relevant to technological advances. Therefore, joint efforts are needed from the government, educational institutions, and the industrial world to overcome this challenge so that pharmacy education can prepare its graduates well to face the increasingly digitalized world of work.

Pharmacist Digital Skills

The gap between the competencies taught in pharmacy education and the digital skills needed in the field is a major challenge in preparing pharmacists to face the digital era. Most pharmacy education still emphasizes traditional skills such as understanding pharmacology, compounding drugs, and direct patient management, while in the workplace, pharmacists are now expected to have broader digital skills. Many pharmacists are trained in aspects of conventional pharmacy, but are not taught skills in the use of pharmacy information systems, digital-based patient data management, or artificial intelligence (AI)-based pharmacy applications. In fact, in modern health facilities, pharmacists need to master software to record patient data, provide data-based

recommendations, and interact with telemedicine systems (Ahliyah, AA 2022).

In addition, pharmacy education curricula often do not provide in-depth digital skills training, such as the use of electronic medical records (EMR), cloud-based pharmacy applications, or the application of big data in decision-making. Skills in digital data security and patient privacy are also lacking in pharmacy education, even though they are very important in safe and regulatory pharmacy practices, such as GDPR or HIPAA. The faster pace of technological development compared to updates in the curriculum is another factor that exacerbates this gap. Digital pharmacy practices are growing rapidly, while educational curricula are still struggling to keep up with the pace of change. Furthermore, the role of pharmacists in digital health systems, such as using telemedicine applications or providing digital-based health consultations, is often not optimally recognized in the curriculum. This causes pharmacists to have to learn new digital skills after entering the workforce. To address this gap, pharmacy education curricula need to be updated by including relevant digital skills training and introducing the role of pharmacists in digital health systems. In this way, pharmacists will be better prepared to face the needs and challenges in the field (Prasetio, BH 2023).

Integration of digital literacy and technology skills in pharmacy education.

Integration of digital literacy and technological skills in pharmacy education is essential to prepare pharmacists to face challenges in the digital era. With rapid technological advances, the world of pharmacy is also experiencing major changes, both in terms of professional practice, patient care, and medical data management. Therefore, pharmacy education must be able to integrate digital literacy and technological skills to produce pharmacists who are competent in facing an increasingly digitalized world (Astiena, AK, & Hadiguna, RA 2024).

1. Digital Literacy in Pharmacy Education

Digital literacy is the ability to use a variety of digital devices and technology applications effectively and wisely. In the context of pharmacy education, digital literacy includes an understanding of how to use technology to access pharmaceutical information, communicate with patients or fellow professionals, and manage medical data securely. By incorporating digital literacy into the curriculum, pharmacy students can learn how to use digital platforms to find the latest information on medications, drug interactions, and clinical guidelines. In addition, digital literacy also includes skills in operating electronic medical record (EMR) systems, pharmacy software, and other healthcare applications used in the workplace.

2. Technology Skills in Pharmacy Practice

In addition to digital literacy, technology skills in pharmacy practice are also essential. This includes the ability to use a variety of tools and software that are increasingly used in healthcare, such as computer-based medication dispensing applications, telepharmacy, and cloud-based pharmacy management systems. Pharmacists must also be proficient in using technology tools for remote communication with patients, especially in telemedicine or remote pharmacy service settings. These skills will enable pharmacists to provide more efficient medication consultations, monitor patient therapy, and provide online health education.

3. Use of Big Data and Artificial Intelligence (AI)

Integration of technology into pharmacy education also includes an introduction to big data and artificial intelligence (AI). Pharmacy students should be equipped with skills in processing and analyzing big data to aid evidence-based decision-making in drug

therapy. Using big data, pharmacists can identify drug use trends, monitor side effects, and recommend more appropriate treatments for patients. AI also has the potential to streamline the drug compounding process, design more personalized therapy regimens, and predict risky drug interactions. Teaching these skills to pharmacy students will enable them to adapt to technological advances in their practice.

4. Data Security and Digital Ethics

Data security is an important aspect of digital literacy that needs to be taught to pharmacy students. In digital pharmacy practice, pharmacists must ensure that patient information is properly protected and managed in accordance with applicable regulations, such as HIPAA (Health Insurance Portability and Accountability Act) or GDPR (General Data Protection Regulation). Pharmacy education should include topics on digital ethics, including how to securely manage personal data, prevent data breaches, and understand patient rights regarding their medical information. This is especially important given the high level of reliance on technology to store and manage patient data.

5. Technology Based Learning

Technology-based learning can also be integrated into pharmacy education to enhance students' learning experiences. E-learning platforms, interactive simulations, and mobile applications can be used to enhance theoretical and practical learning. For example, virtual reality (VR) or augmented reality (AR)-based simulations can be used to teach laboratory skills or patient communication, allowing students to practice their skills in a more realistic and safe environment. This approach helps pharmacy students become better prepared for real-world challenges in their profession.
(Nur, MK, et al. 2025).

Digital competency improvement program for pharmacists who are already working

Digital competency improvement programs for pharmacists who are already working are very important to ensure that they remain relevant to technological developments in the pharmaceutical world. With the rapid digital transformation in the health sector, pharmacists need to have skills and knowledge that can support their practice, both in managing patient data, using pharmaceutical technology, and communicating with patients using digital platforms (Dominikus, WS 2023). Here are some important elements in a digital competency improvement program for pharmacists who are already working:

1. Training in the Use of Health Information Systems

Health information systems, such as electronic medical records (EMR), cloud-based pharmacy management systems, and drug therapy management applications, are increasingly common in hospitals, pharmacies, and other healthcare facilities. This training program aims to provide pharmacists with an understanding of how to operate and utilize these information systems in managing medications, monitoring patient therapy, and recording medical data efficiently and securely. This training also involves an understanding of data security and related regulations, such as HIPAA or GDPR, to ensure the privacy and security of patient data (Handayani, PW 2023).

2. Introduction and Mastery of Telepharmacy

Telepharmacy is the use of remote communication technology to provide pharmaceutical services, such as drug consultations and therapy management. Digital competency improvement programs should teach pharmacists how to use telepharmacy platforms to consult with patients, provide information about medications, and monitor

medication use remotely. This training is especially important with the increasing need for remote health services that allow pharmacists to continue providing services to patients even without face-to-face contact (Wijaya, H., et al. 2023).

3. Big Data and Analytics Training

Big data and analytics play a critical role in evidence-based decision-making in pharmacy. Digital competency enhancement programs should include training on how pharmacists can use data analytics to identify drug use trends, analyze therapy effectiveness, and monitor side effects or drug interactions. Pharmacists who are skilled in data analysis can provide more accurate recommendations in managing patient therapy, improve medication safety, and minimize risks (Wibowo, TS, MM, MS, & Farm, M. 2024).

4. Understanding Artificial Intelligence (AI) in Pharmacy Practice

Artificial intelligence (AI) is increasingly being used in pharmacy practice to formulate drug prescriptions, analyze drug interactions, and provide personalized therapy recommendations. This training program aims to equip pharmacists with a basic understanding of how AI works, as well as AI applications that can help them in their daily work. With AI mastery, pharmacists can be more efficient in prescribing drugs and monitoring their effectiveness, as well as providing more appropriate healthcare services.

5. Digital Communication Skills Development

Effective communication with patients, especially through digital platforms, is an important skill in the digital age. This training program will help pharmacists develop good long-distance communication skills, whether through email, video calls, or other digital health platforms. These skills are essential in providing medication education, answering patient questions, and ensuring patients understand how to use medications correctly (Laksmi, LPD 2023).

6. Certification and Special Courses

To ensure that pharmacists have adequate digital competencies, competency enhancement programs can also include professionally recognized certifications and specific courses. These courses can cover topics such as the use of pharmacy management systems, medical data security, technology-based pharmacy applications, and the use of other digital tools in pharmacy practice. These certifications not only enhance pharmacists' skills but also increase their credibility in the workplace.

7. Continuous Improvement of Digital Literacy

As technology continues to evolve, digital competency enhancement programs for pharmacists must be ongoing. These programs can include regular training or access to the latest learning materials to keep pharmacists abreast of the latest trends and innovations in digital pharmacy. Online learning or e-learning platforms can be used to allow pharmacists to access training anytime and anywhere, according to their work schedule.

8. Developing Collaboration with Other Health Professionals

Pharmacists must learn to work with other healthcare professionals using the same digital tools. This program may involve training on how to collaborate digitally with physicians, nurses, and other healthcare professionals through technology-based communication and collaboration platforms. This collaboration is critical in providing holistic and coordinated healthcare services (Amin, M., et al. 2021).

CONCLUSION

Pharmacy education needs to undergo a major transformation to prepare competent pharmacists in the digital era. Integration of technology into the curriculum, such as the use of e-learning, blended learning, augmented reality (AR), and virtual reality (VR), provides a more flexible and practical learning experience for students. In addition, mastery of technologies such as big data, artificial intelligence (AI), and pharmacy information systems must be an important part of the curriculum to support evidence-based decision-making and improve the efficiency of health services. Digital literacy and an understanding of data security regulations such as GDPR and HIPAA are also essential so that students and pharmacists can manage patient data safely. However, pharmacy education still faces various challenges in implementing technology, such as limited infrastructure, resistance to change, and the mismatch between the curriculum and practical needs in the field. The gap between the competencies taught in pharmacy education and the digital skills needed in the world of work adds to the challenges in preparing pharmacists to face an increasingly digitalized profession. Therefore, the pharmacy education curriculum needs to be continuously updated and adjusted to the latest technological developments. In addition, it is important to improve training programs for pharmacists who are already working, so that they remain relevant to rapid technological changes. Training in the use of health information systems, telepharmacy, big data, and artificial intelligence is a crucial step in ensuring pharmacists can leverage technology to provide the best service to patients. Overall, the readiness of pharmacy education in facing the digital era requires collaboration between educational institutions, government, and the health industry to overcome challenges and create an environment that supports the development of digital skills. With an adaptive approach and continuous curriculum updates, pharmacy education graduates will be better prepared to face the demands of a world of work that is increasingly integrated with technology.

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