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The Application of Regenerative Technology in Tissue Engineering in Indonesia: Embracing an Era of More Personalized and Effective Medicine

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ABSTRACT

The use of digital media in health communication has become a significant area of research, particularly in understanding how medical professionals and patients interact through these platforms. However, existing studies often focus on quantitative measures, leaving the personal and professional experiences of healthcare practitioners and patients during digital communication underexplored. This study aims to address this gap by exploring the lived experiences of healthcare practitioners and patients in using digital tools for communication. Using a phenomenological approach, this research investigates the deeper meanings and perceptions associated with the adoption of digital media in healthcare settings. Through in-depth interviews with healthcare practitioners and patients, several themes emerged, including the challenges of technology adoption, trust-building in digital interactions, and the evolving nature of doctor-patient relationships. These findings contribute to a richer understanding of the complexities surrounding digital media use in healthcare and highlight the need for more qualitative research to better inform policies and practices in the digital health domain.

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INTRODUCTION

Regenerative medicine and tissue engineering are rapidly evolving fields of study in recent decades, with the promise of regenerating or replacing damaged tissues or organs caused by injury or degenerative diseases (Abu Awwad dkk., 2020). These technologies, which include the use of stem cells, biomaterials, and bioprinting, offer great potential in treating diseases that were previously considered incurable. While regenerative medicine leverages the body's innate repair mechanisms, tissue engineering focuses on creating artificial tissues that integrate seamlessly with human physiology (Agostinacchio et al., 2024). These advancements hold the potential to revolutionize treatment approaches for conditions like cartilage damage, nerve disorders, and heart disease.

However, despite the immense potential of these technologies, significant challenges remain in their application in the medical field (Bojedla dkk., 2022). Limited biological resources such as high-quality stem cells, constraints in the production of compatible biomaterials, and strict regulatory hurdles are major obstacles faced by medical practitioners (Cassotta dkk., 2020). Furthermore, although these technologies offer new hope for patients, concerns about long-term side effects and the ethical implications of their application persist. In this context, the subjective experiences of the medical practitioners and patients involved in the use of these technologies become crucial to understand more deeply.

The phenomenological approach, which focuses on subjective experiences and the meanings individuals attach to a phenomenon, provides valuable insights into how these technologies are accepted and applied in the medical field (Gangrade dkk., 2024). While much of the previous research

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has employed quantitative approaches to measure the effectiveness of these technologies, few studies have investigated the direct experiences of medical practitioners involved in their implementation. This study aims to fill this gap by exploring the experiences of medical practitioners using regenerative medicine and tissue engineering technologies in clinical practice. Through a phenomenological approach, it is expected that a deeper understanding will be gained regarding the challenges, hopes, and perceptions arising from the application of these technologies in the field.

Research on subjective experiences in medical phenomena, particularly related to the application of innovative technologies such as regenerative medicine and tissue engineering, has become an increasingly important field (Ghollasi & Poormoghadam, 2022). Exploring the meanings attributed by medical practitioners to the use of these technologies not only provides insights into the effectiveness of these technologies but also reveals the challenges they face in their implementation. The phenomenological approach allows for a deeper understanding of how individuals interpret and respond to these technologies, which are often tied to their feelings, perceptions, and emotional experiences. In this context, phenomenology offers a way to view medical technology not only as a tool but also as part of the lived experience of medical practitioners and patients.

However, this approach also faces significant methodological challenges (Iacobazzi dkk., 2021). One of the main challenges in exploring deep meanings and experiences is the limitation of data that can be obtained through quantitative approaches, which tend to focus on objectively measurable outcomes, such as therapy success rates or the number of patients receiving the therapy. This quantitative approach is less capable of capturing the subjective dimensions of medical practitioners' experiences, such as their feelings of anxiety or uncertainty regarding long-term risks, or the ethical concerns they may face. Furthermore, limitations in structured interviews or surveys with predefined response options reduce the ability to delve into the deeper meanings of medical practitioners' experiences.

These limitations make many previous research methods, which have been more focused on statistical analysis or clinical outcomes, less effective in fully understanding the essence of the phenomenon (Koch & Koster, 2021). Therefore, the phenomenological approach becomes highly relevant in this context, as it can explore the perceptions, personal experiences, and meanings attributed by individuals to the use of regenerative technologies, as well as how this affects their daily medical practice. Thus, phenomenology not only offers a way to understand the clinical outcomes of technology but also helps to comprehend how this technology is perceived and implemented by medical practitioners.

Although various practical approaches have been used to address the challenges in the implementation of regenerative medicine and tissue engineering technologies, most existing research has focused more on evaluating clinical outcomes and quantitative data, such as therapy success rates or patient recovery rates (Launer-Wachs dkk., 2023). These approaches provide a clear picture of the objective effectiveness of the technology, but they often fail to capture the subjective experiences of medical practitioners involved in the process of implementing these technologies. For example, while there is an understanding of the success of these technologies in experimental or clinical trial contexts, little is known about the feelings, challenges, and uncertainties faced by medical practitioners when dealing with the technical, ethical, and regulatory issues that accompany the adoption of new technologies.

This limitation has resulted in an incomplete and non-holistic understanding of the phenomenon. The use of quantitative approaches or even clinical trial-based approaches is not sufficient to explore the deep subjective dimensions of experience that influence medical decisions and the interactions between practitioners and patients. Therefore, while there is a wealth of quantitative data supporting the potential of this technology, the understanding of how this technology is perceived by those who use it in clinical settings remains very limited.

To address this, an alternative and more appropriate solution is to adopt a phenomenological approach. This approach allows for the exploration of the essence of medical practitioners' experiences, emphasizing the meanings they attach to the use of regenerative medicine and tissue engineering technologies. By deeply exploring subjective experiences, phenomenology provides a

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more holistic insight into the challenges, hopes, and perceptions formed within social and medical contexts. This is an important step in fully understanding how these technologies are accepted and implemented in medical practice, as well as their impact on the medical professionals directly involved.

Research on the application of regenerative medicine and tissue engineering technologies in medical contexts has largely focused on technical aspects and clinical outcomes. Several previous studies have examined the success of therapies based on quantitative parameters, such as tissue regeneration rates or the number of patients showing recovery after treatment. However, few studies have investigated the subjective experiences of medical practitioners directly involved in the process. Existing literature indicates that while these technologies hold promise, many practitioners face significant ethical and technical challenges in their implementation (Greenhalgh et al., 2017). Therefore, it is important to explore how they interpret and address these challenges in their daily practice.

The phenomenological method is chosen for this study due to its ability to explore in-depth experiences of subjects involved in the application of new technologies. Phenomenology allows the researcher to understand the essence of the experience, rather than merely the outcomes or effects of the technology itself. Through in-depth interviews and thematic analysis, this approach will uncover the meanings attributed by medical practitioners to the application of regenerative medicine and tissue engineering technologies. By focusing on their subjective experiences, this method will help answer the question posed in the "Knowledge Gap" section: how do medical practitioners experience, perceive, and face the challenges in adopting this technology?

This article is structured into several interconnected sections to build a comprehensive understanding of the phenomenon under study. Starting with an introduction that explains the context of the phenomenon, the article will outline the phenomenological methodological approach used, as well as the process of data collection and analysis. Subsequently, the research findings will be presented in a discussion interpreting the results based on the experiences of medical practitioners. Finally, the conclusion will summarize the insights gained from the findings and provide recommendations for further development in the clinical application of this technology.

RESEARCH METHODS

Study Design

A phenomenological approach was chosen for the design of this research, as this method allows for an in-depth exploration of the subjective experiences of medical practitioners in implementing regenerative medicine and tissue engineering technologies (Maas dkk., 2023). The primary focus of phenomenology is to understand the meaning individuals assign to specific phenomena within the context of their everyday lives. This approach is relevant to answering the research questions regarding how medical practitioners experience the use of these technologies and the challenges they face. To address potential challenges in the phenomenological approach, such as researcher bias or over-interpretation, a rigorous process of bracketing was employed. This involved setting aside preconceptions and focusing solely on the data presented by the participants. Member checking was also conducted to ensure the accuracy of the interpreted themes.Descriptive phenomenology was employed in this study to explore the direct experiences of medical practitioners, without over-interpretation or bias toward the data. Thus, this approach allows for a deeper understanding of the feelings, perceptions, and experiences of medical practitioners related to the emerging medical technologies.

Participants

The participants in this study consisted of 10 specialist doctors and 5 scientists involved in the research and development of regenerative medicine and tissue engineering technologies in Indonesia. Participants were selected using a purposive sampling approach, with inclusion criteria involving medical professionals who have direct experience in applying these technologies in clinical practice or

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research. Exclusion criteria included individuals who had not participated in clinical trials or the application of regenerative medicine technologies in medical contexts. The demographic profile of participants included various medical backgrounds, including orthopedic specialists, regenerative medicine specialists, and biotechnologists, aged between 35 and 55 years. All participants had practical experience with this technology, either in clinical trials or in laboratory research settings.

Data Collection

Data were collected through in-depth interviews conducted in person with each participant. These interviews used semi-structured interview guidelines, allowing for flexibility in exploring the subjects' experiences more thoroughly while maintaining focus on the research topic. The interviews were conducted in comfortable and conducive settings, such as hospitals, laboratories, or private workspaces of the participants. The duration of the interviews ranged from 45 to 60 minutes, and all interview sessions were recorded with the participants' consent to ensure accuracy in data collection. In addition to interviews, observations were also conducted at several hospitals and laboratories where the technology is being applied, to provide a clearer picture of daily practices and the challenges faced in using this technology.

Data Analysis

The data were analyzed using thematic analysis to identify and explore key themes that emerged from the interviews and observations. The analysis began with verbatim transcription of the interviews, followed by data coding to identify patterns and themes relevant to the experiences of medical practitioners (Mahajan dkk., 2024). The analysis steps included grouping data into thematic categories that described the perceptions, challenges, and expectations of medical practitioners regarding regenerative medicine and tissue engineering technologies. Data were also analyzed within the context of diffusion of innovation theory to understand the factors influencing the adoption of new technologies in medical practice. The use of NVivo software facilitated the systematic organization and coding of the data, but the primary focus remained on gaining a deep understanding of the participants' experiences.

Ethics

This study adhered to both international and local research ethics standards. Ethical approval was obtained from the relevant research ethics committee before data collection commenced. All participants provided written consent after receiving clear information regarding the research's objectives, the interview procedures, and their rights as participants, including the right to withdraw at any time without consequence. All collected data were kept confidential, and participants' identities were anonymized to maintain their privacy. Steps were taken to address ethical challenges, such as ensuring that sensitive information shared by participants was securely stored and accessible only to the research team. The study also ensured that the data collected would only be used for the purposes of this research, in accordance with the applicable ethical research principles.

RESULTS

Optimism and Hope Regarding the Potential of Regenerative Medicine

Most of the medical practitioners involved in this study expressed great optimism about the potential of regenerative medicine technology in treating degenerative diseases. They believe that this technology could provide long-term solutions for patients with conditions that are difficult to cure, such as tissue damage due to injuries or chronic diseases. As Dr. A (orthopedic specialist) stated, "This technology provides new hope, especially for patients who previously had no effective treatment options. Regenerative medicine could be a turning point in the therapy of damaged tissue healing." In addition, Dr. B (biotechnology scientist) expressed his belief that bioprinting technology, which allows for the printing of artificial tissue, will open up extraordinary possibilities in tissue engineering, "We can print organs or tissues tailored to the patient's needs, making treatment more personalized and targeted." This statement highlights the high expectations for the therapeutic applications of the increasingly advancing technology.

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Challenges in Regulatory Aspects and Medical Standards

However, despite the optimism, medical practitioners also raised significant challenges they face, particularly concerning strict regulations and the lack of fully established medical standards. Some doctors mentioned that while the technology shows promising potential, its clinical implementation is still limited by regulatory uncertainty and the absence of clear guidelines. As Dr. C (regenerative medicine specialist) revealed, "We often face ambiguities in regulation. How can this technology be widely accepted if its operational standards have not yet been established?" Concerns about this issue are reinforced by the finding that many hospitals or clinics are still hesitant to implement stem cell therapy in routine patient treatment. According to Dr. D (biomedical scientist), "Strict regulations make many medical facilities reluctant to innovate, as they are concerned about the legal implications and potential risks."

Ethical and Safety Issues of Cellular Therapy

In addition to regulatory challenges, ethical and safety concerns are also major issues in the application of regenerative medicine, particularly with regard to stem cell use and cellular therapy. Medical practitioners expressed their concerns about the potential long-term side effects that might arise from using this technology. Dr. E (specialist doctor) stated, "Although its benefits appear promising, we must be cautious about potential long-term side effects. What we do now may have impacts on patients in the future." This view reflects the uncertainty that still surrounds the development of regenerative technologies, especially concerning their safety. Moreover, some medical practitioners voiced concerns about the ethical implications of using untested stem cell-based therapies, particularly regarding the possibility of experimentation on vulnerable patients. "There are many questions about who is responsible if this therapy turns out to be unsafe," said Dr. F (regenerative specialist).

Patient Perceptions of Regenerative Therapy

Field observations also revealed uncertainties among patients regarding regenerative therapy. Many patients were skeptical about the effectiveness and safety of the therapy, considering it is still in the experimental phase and has not been fully tested. Interviews with several patients revealed their concerns about potential side effects after the procedure. One patient involved in a stem cell therapy trial shared, "I am anxious about what will happen after this therapy. No one can guarantee whether it will actually work or if it will have adverse effects." This uncertainty highlights the importance of better communication between medical practitioners and patients regarding the risks and benefits of regenerative therapy.

The findings of this study confirm that although regenerative medicine and tissue engineering technologies offer great potential for treating degenerative diseases, significant challenges related to regulation, ethics, and patient acceptance remain major obstacles to their implementation. Medical practitioners are highly optimistic about the benefits of this technology, yet they also feel burdened by regulatory uncertainties and concerns about long-term side effects. Patients, on the other hand, express greater doubts and anxiety regarding the safety and effectiveness of these therapies. Overall, the experiences of medical practitioners and patients reflect the tension between the hopes and challenges in the application of this medical technology.

DISCUSSION

The main findings of this study indicate that the implementation of regenerative medicine and tissue engineering technologies in medical practice has a complex impact on the experiences of medical practitioners, focusing on technical, ethical, and regulatory challenges (Maier dkk., 2024). Medical practitioners feel optimistic about the potential of these technologies, but also face anxiety and uncertainty regarding long-term effects, as well as limitations in infrastructure and training (Mishchenko dkk., 2022). This addresses the key question raised in the Introduction section about

how medical practitioners experience the implementation of this technology and the challenges they face in a clinical context.

These findings provide deep insights into how medical practitioners perceive and interpret the application of regenerative technologies in the medical field (Pashchenko dkk., 2022). Most practitioners are aware of the immense potential of these technologies in addressing degenerative diseases, but they also recognize the practical challenges in their use, such as the lack of clear regulations and the limitations of supporting medical infrastructure. They often find themselves at the crossroads between hope for these technologies and concerns regarding potential side effects, as well as ethical questions surrounding stem cell-based therapies and biomaterials. Therefore, these experiences are not limited to technical aspects alone, but also involve crucial ethical and regulatory considerations that are essential for the successful adoption of technology in daily medical practice.

When comparing the findings of this study with previous literature, our results align with the research of Greenhalgh et al. (2017), which revealed that although regenerative medicine technology offers new hope, challenges in regulation and clinical understanding remain significant barriers to its implementation (Patil dkk., 2024). However, this study adds an important dimension by deepening our understanding of the subjective experiences of medical practitioners, which has been less explored in previous studies. Rogers' (2003) Diffusion of Innovations theory can also provide a framework for understanding how anxiety and uncertainty related to the adoption of new technologies may influence the decision-making of medical practitioners. These findings support the view that the implementation of new technologies in medicine is not only influenced by technical and efficiency aspects, but also by social, ethical, and psychological factors that affect the adoption of technology in a clinical context.

Implications of the Findings

The implications of these findings are significant both clinically and socially. From a practical perspective the findings highlight the urgent need for the development of clearer regulations and more comprehensive training for medical practitioners in the implementation of regenerative medicine and tissue engineering technologies (Petretta et al., 2023). One practitioner remarked, “Without proper training, even the best technology won’t reach its potential because we don’t fully understand how to use it safely and effectively.” Socially, the findings also reveal that the adoption of new technologies in the medical field is not solely dependent on technical aspects, but also on a deeper understanding of the social and cultural context of the acceptance of such technologies. The experiences identified in this study provide valuable insights for increasing public awareness and education regarding the potential and risks of these medical technologies. The relevance of these findings is significant not only for Indonesia but also for countries with developing healthcare systems, where new technologies like regenerative medicine could present great opportunities in patient care, yet require attention to the challenges arising from their management.

Study Limitations

While the findings of this study contribute significantly to the understanding of medical practitioners' experiences regarding the implementation of regenerative medicine technologies, several limitations need to be considered (Shafiee, 2020). One limitation is the relatively small sample size, consisting of only 10 specialist doctors and 5 scientists. This may limit the generalizability of the findings to a broader population. Additionally, this study was conducted solely in Indonesia, which has a healthcare system and regulatory environment that differ from those of other countries, meaning the findings may not fully apply in a global context. The phenomenological methodology used also limits the findings to the subjective experiences and personal interpretations of the participants, meaning that broader perspectives on the technology beyond the perceptions of medical practitioners may not be fully captured (Susapto dkk., 2021). These limitations open opportunities for future research that can expand the sample size, include more diverse contexts, and further explore the social factors influencing the implementation of medical technologies in different parts of the world.

Prospective Statements for Future Research

This study paves the way for further exploration of the challenges and potential of regenerative medicine technologies in the medical field (Weber dkk., 2023). Future research could

broaden the scope of these findings by involving various types of medical practitioners from different specialties, as well as patients involved in the adoption process of these technologies. Additionally, further research could delve deeper into the interactions between social, cultural, and ethical factors influencing medical decision-making in the application of stem cell-based therapies. By examining the experiences of both patients and practitioners from a broader perspective, future studies could provide a more comprehensive understanding of how these technologies can be adopted more effectively, as well as their impact on patient quality of life and the sustainability of healthcare systems. This research could also serve as a foundation for developing clearer policies and guidelines to support the adoption of innovative technologies in healthcare.

CONCLUSION

This study focuses on the experiences of medical practitioners regarding the adoption of regenerative medicine and tissue engineering technologies in Indonesia, with the aim of understanding their subjective meanings in the implementation of these technologies. The main findings of this research reveal that while these technologies offer great potential in medical treatment, medical practitioners face challenges related to effectiveness, long-term risks, and the need for clearer regulations. This study addresses the gaps in previous research by highlighting the social and cultural aspects that influence the acceptance of these technologies, as well as the importance of training and support for medical practitioners. The findings also contribute to the development of better policies for the implementation of new medical technologies. For future research, expanding the sample size and considering international contexts could provide further insights into the challenges faced in adopting advanced medical technologies. For future research, conducting multi-country comparisons could provide valuable insights into how regulatory, cultural, and economic contexts influence the adoption of regenerative medicine technologies. Exploring diverse patient demographics, including age, socioeconomic status, and cultural background, would help uncover variations in perceptions and acceptance of these technologies. Additionally, longitudinal studies tracking the experiences of both practitioners and patients over time could shed light on how challenges evolve with the integration of these technologies into routine practice. Another important area for exploration is the role of interdisciplinary collaboration among medical practitioners, engineers, and policymakers in addressing technical and ethical challenges. Finally, investigating the perspectives of policymakers and healthcare administrators could provide a more comprehensive understanding of systemic barriers and opportunities for improving the implementation process. Thus, this study opens opportunities for further research that could enrich the understanding of the application of innovative technologies in the medical field.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

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