Journal of Population Therapeutics & Clinical Pharmacology

RESEARCH ARTICLE
DOI: 10.53555/v5yt2296

TRANSFORMING PAKISTAN'S MEDICAL LANDSCAPE THE CONVERGENCE OF PHYSIOLOGY, PHARMACOLOGY, AND HISTOPATHOLOGY FROM DIGITAL PIONEERING TO COMPUTATIONAL EXCELLENCE

Dr Saima Nadeem[1*], Dr Fiaz Ahmad[2], Dr Sofia Jadoon[3], Dr Nighat Parveen[4], Dr Bilquees Saba[5], Dr Saima Bashir[6]

[1*]Assistant Professor, Department of Pathology, Khyber Girls Medical College, Peshawar Pakistan
[2]Assistant Professor, Department of Pathology, Ayub Medical College, Abbottabad Pakistan
[3]Assistant Professor, Department of Anatomy, Abbottabad International Medical College Abbottabad Pakistan
[4]MBBS, MPhil, Senior Lecturer Physiology, Abbottabad International Medical College, Abbottabad Pakistan
[5]Senior Registrar, Consultant Nephrologist, Ziauddin University Hospital, Karachi Pakistan
[6]Department of Pathology, Gomal Medical College, Dera Ismail Khan, Pakistan

***Corresponding Author:** Dr Saima Bashir
*Department of Pathology, Gomal Medical College, Dera Ismail Khan, Pakistan
Email address: doc.saimabashir@gmail.com

ABSTRACT

Background: Teaching and clinical procedures are changing as a result of the use of digital and computational technology in medical education. This research looks at how digital technology is now being used in the departments of physiology, pharmacology, and histology at medical institutions in Khyber Pakhtunkhwa (KPK), Pakistan.

Methods: A survey of 227 students from public (Khyber Medical College, Ayub Medical College) and private (Rehman Medical College, Peshawar Medical College, Frontier Medical College) medical schools was part of the mixed-methods technique that was used. The availability, application, and perceived advantages of digital technologies were evaluated in the survey. Thirty stakeholders participated in semi-structured interviews that yielded qualitative insights on opportunities and problems.

Results: Seventy-two percent of respondents said they had access to digital materials; availability was greater in public institutions (78.1%) than in private colleges (63.4%). The most frequent users of digital tools were found in the fields of histology (70.8%), physiology (63.9%), and pharmacology (54.8%). Improved learning outcomes (81.5%) and diagnostic accuracy (77.3%) were among the benefits. Reluctance to change (48.3%), insufficient training (58.2%), and few resources (65.9%) were among the obstacles. Senior faculty members at public universities were more resistant to them, while financial restrictions plagued private schools.

Conclusion: Digital technologies are improving medical education in KPK, but to fully realize their potential and get beyond current obstacles, increased training and strategic expenditures are required.

Keywords: Digital Technologies, Medical Education, Khyber Pakhtunkhwa, Digital Integration, Educational Challenges

Introduction

The medical sciences are undergoing an unparalleled metamorphosis, propelled by the rapid progress of digital technology and computational techniques. Disciplines like physiology, pharmacology, and histology are going through a significant transition in this innovative age, not only internationally but also in Pakistan [1]. Pakistan's medical education and practice have always been based on traditional methods, which mostly rely on manual procedures and traditional knowledge. But as digital tools and computational technology proliferate, the need of incorporating these advancements into medical practice and teaching is becoming more apparent [2]. The three fundamental pillars of medical science are physiology, pharmacology, and histology. Each is essential to comprehending the human body, illness processes, and treatment approaches. Histopathology enables the microscopic inspection of tissues to detect disorders, pharmacology gives a thorough knowledge of medication effects and interactions, and physiology offers insights into the functioning elements of the body [3, 4]. The confluence of these fields, made possible by computational and digital technology, offers Pakistani medical practitioners a rare chance to improve the precision, effectiveness, and breadth of their work [5].

Despite these advantages, Pakistan's adoption of digital and computational technologies in these disciplines has been sluggish due to a number of issues, including a lack of funding, insufficient training, and opposition to change [6-8]. Nonetheless, new initiatives in digital pioneering, including technology like as artificial intelligence, computer simulations, and digital photography, are starting to change the game [9]. These developments are helping medical professionals diagnose and treat patients better, but they are also boosting student learning experiences by giving them access to creative and engaging ways to get a deeper comprehension of difficult subjects [10]. Furthermore, Pakistani medical research and practice stand to benefit greatly from computational brilliance, which is typified by the use of big data, machine learning, and sophisticated algorithms. Through the use of these technologies, healthcare providers may examine enormous volumes of data in order to spot trends, forecast results, and create customized treatment regimens, all of which enhance patient care and results [11, 12]. By simulating drug interactions and forecasting side effects, for example, the incorporation of computational techniques in pharmacology considerably lowers the risks involved in clinical trials and medication development [13, 14].

In this regard, changing Pakistan's medical environment calls for a multipronged strategy that includes regulatory changes, capacity development, technical improvements, and cultural changes within the medical profession. This paper examines how advances in digital and computational technologies are influencing the fields of physiology, pharmacology, and histology. It also discusses the advantages and disadvantages of these developments. Through an analysis of the present status of these fields in Pakistan and an investigation of potential future paths, our goal is to offer a thorough synopsis of how medical education and practice can be revolutionized by digital innovation and computational prowess, ultimately leading to better healthcare outcomes in the nation.

Methodology

In order to investigate the present status of physiology, pharmacology, and histology in Pakistan, this research was constructed as a qualitative and quantitative analysis with an emphasis on the incorporation of digital and computational technologies into these domains. Six months, from January to June 2024, were dedicated to the research at a few public and private medical institutes in Khyber Pakhtunkhwa (KPK), Pakistan.

Study Design and Participants: The research used a mixed-methods approach, combining qualitative interviews with survey-based quantitative data gathering. Medical personnel, instructors,

and students from departments of physiology, pharmacology, and histology comprised the sample. To guarantee that individuals with different degrees of expertise and exposure to digital and computational technologies were included, a purposive sample strategy was used. Five medical colleges in KPK were used to gather the data: three private colleges, Rehman Medical College (RMC), Peshawar, Peshawar Medical College (PMC), and Frontier Medical College (FMC), Abbottabad, and two public colleges, Khyber Medical College (KMC), Peshawar, and Ayub Medical College (AMC), Abbottabad. The quantitative survey aimed to include 300 people in total, with 100 volunteers from each of the three disciplines—pharmacology, histology, and physiology. In-depth semi-structured interviews were carried out with thirty key informants, including department heads, senior educators, and digital technology professionals, for the qualitative component.

Data Collection: A systematic questionnaire intended to evaluate the present use of digital tools and computational technologies in the disciplines of physiology, pharmacology, and histology was used to gather the quantitative data. The questionnaire addressed a number of topics, such as the accessibility of digital resources, how often they are used, their perceived advantages, adoption hurdles, and how these technologies affect clinical and educational results. Participants in the poll received it electronically via university email lists, and answers were gathered anonymously to maintain privacy. The survey's data collection was finished in three months, and almost 75% of respondents answered.

Depending on the participants' availability and location, semi-structured interviews for the qualitative component were done in-person or over video conference. To find out how participants felt about the integration of digital and computational technologies, what obstacles they experienced, and what they thought might be improved going forward, an interview guide was created. With the participants' permission, each interview was audio recorded and lasted between forty-five and sixty minutes. For theme analysis, the verbatim transcriptions of the interviews were used.

Data Analysis: Software for statistical analysis was used to examine the quantitative data (such as SPSS or R). The demographic details of the participants and the general use of digital and computational technology in each subject were compiled using descriptive statistics. To find significant variations in technology adoption across the three disciplines and between various kinds of institutions (public vs. private), inferential statistics were used, such as chi-square tests and ANOVA.

Thematic analysis was used to examine the qualitative data. To guarantee the authenticity and trustworthiness of the results, two researchers independently coded the transcripts. Important themes about the advantages, difficulties, and potential applications of digital and computational technologies in pharmacology, histology, and physiology were found. Any differences in the researchers' coding were settled using a consensus-building process.

Results

In Khyber Pakhtunkhwa (KPK), Pakistan, a few public and private medical institutions were chosen, and the integration of digital and computational technologies in the domains of physiology, pharmacology, and histology was investigated. The survey's quantitative results and the semi-structured interviews' qualitative insights are provided separately in the findings section. The poll received responses from 227 participants, with an estimated response rate of 75.6%. 69 replies were from the histology department, 71 from the pharmacology department, and 87 from the physiology department. Of the respondents, 42% attended private institutions (Rehman Medical College, Peshawar Medical College, and Frontier Medical College) and 58% attended public colleges (Khyber Medical College and Ayub Medical College).

According to the poll, around 72.3% of participants said their departments had access to digital resources such e-books, online databases, and digital microscopes. There was a clear difference between public and private universities; public universities reported having more digital resources available (78.1%) than private universities (63.4%). Table 1 displays the specifics of the accessibility of digital resources.

Table 1: Availability of Digital Resources in Public and Private Medical Colleges

Category	Total Respondents	Public Colleges(%)	Private Colleges(%)
Availability of Digital Resources	227	78.1	63.4

About 63.2% of participants reported using digital tools on a frequent basis for their everyday work in the classroom and in their clinical settings. Each field had a different frequency of use, with histology having the greatest utilization at 70.8%, physiology at 63.9%, and pharmacology at 54.8%. Comparing public and private institutions, the utilization rate of public colleges was somewhat higher, at 68.2% and 57.1%, respectively (see figure 12).

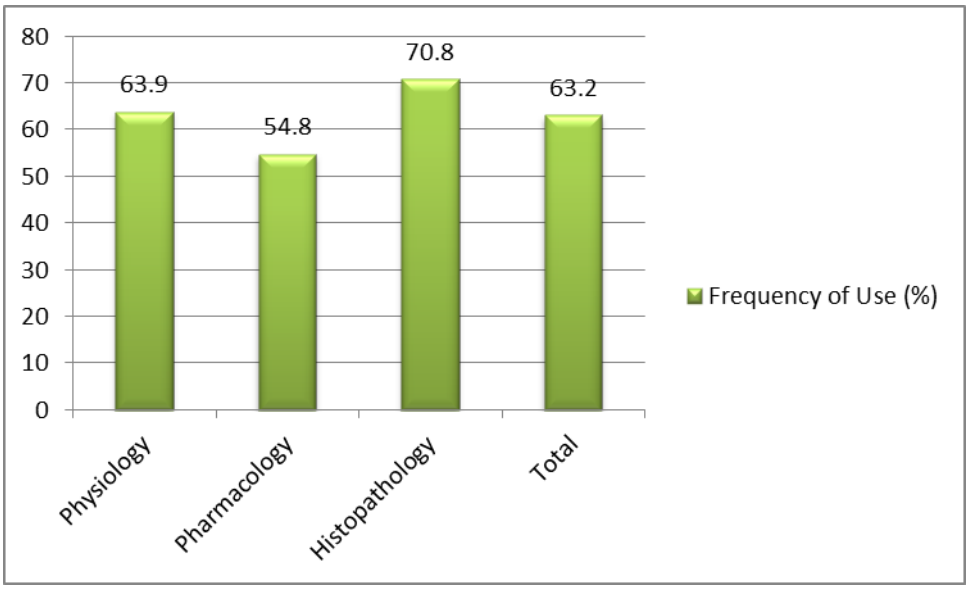

Figure 1: Frequency of Digital Tool Usage Across Different Disciplines

Participants overwhelmingly agreed that combining digital and computational technology would be beneficial. 81.5% of respondents, a sizable majority, felt that these tools had enhanced their capacity for learning and diagnosis. Improved diagnostic accuracy (77.3%), greater access to updated materials (86.7%), and better visualization of difficult topics (81.9%) were among the specific advantages. Table 2 lists all of these advantages in detail.

Table 2: Perceived Benefits of Digital and Computational Technology Integration

Perceived Benefits	Percentage (%)
Improved Learning/Diagnostics	81.5
Enhanced Access to Resources	86.7
Improved Visualization	81.9
Better Diagnostic Accuracy	77.3

Even with the acknowledged advantages, a number of obstacles have been found to prevent the widespread use of digital and computational technology. A significant number of participants,

namely 65.9%, identified the restricted accessibility of sophisticated digital tools and computational resources as a primary obstacle to their adoption. Compared to public universities, where 60.8% of respondents mentioned resource restrictions, private institutions reported 73.2% of respondents indicating the same difficulty. Table 3 provides a summary of the adoption obstacles.

Table 3: Barriers to the Adoption of Digital Technologies in Medical Colleges

Barriers to Adoption	Total Respondents (%)	Public Colleges (%)	Private Colleges (%)
Limited Resources	65.9	60.8	73.2
Lack of Training	58.2	54.1	63.8
Resistance to Change	48.3	52.6	41.3
Lack of Institutional Support	35.6	32.4	38.9

Furthermore, 58.2% of interviewees identified one major difficulty as having insufficient skills to use digital and computational technologies. Better training was clearly needed at private institutions, as indicated by 63.8% of respondents, against 54.1% in public universities. 48.3% of the respondents said that senior faculty members were resistant to implementing new technology. 52.6% of participants at public institutions reported senior staff opposition, compared to 41.3% in private colleges. This resistance was more common in public colleges. Additionally, the research showed that 35.6% of respondents said that institutional support was lacking, especially when it came to finance and infrastructure development, which was impeding the incorporation of new technology.

Thirty semi-structured interviews with department directors, senior educators, and digital technology professionals from the chosen universities comprised the qualitative portion of the research. Deeper understanding of stakeholders' perspectives and experiences with the integration of digital and computational technologies was possible thanks to thematic analysis of the interview data. Participants often emphasized how using digital tools may improve instruction and learning. For example, it has been seen that digital slides and virtual simulations greatly enhance comprehension of intricate physiological processes and medication interactions. Digital pathology has received recognition in the field of histopathology for its capacity to improve diagnosis speed and accuracy, especially in distant locations where access to professional opinions may be restricted. A number of educators highlighted how digital platforms have made it easier for academics and students to collaborate and pursue research opportunities, both domestically and abroad. For data analysis and study, computational tools were considered helpful, particularly in the field of pharmacology.

Notwithstanding the advantages, a number of difficulties in implementing digital and computational technology were observed. Significant infrastructural and resource limitations, such as poor internet access and a dearth of cutting-edge computer technology, were noted by both public and commercial organizations. Budgetary restraints were identified by private institutions as a primary impediment, while public colleges specifically highlighted the issue of inadequate government support. Everyone agreed that more thorough training programs were necessary to raise teacher and student digital literacy. Numerous attendees proposed that holding frequent workshops and seminars might aid in closing the knowledge gap and encourage the efficient use of digital technologies.

Another major obstacle that has evolved is cultural reluctance to embracing new technology. In public universities, where some senior faculty members favored conventional teaching techniques over digital resources, this pushback was increasingly common. Participants observed that a lack of experience with new technology and an unwillingness to alter long-standing routines were often the causes of this resistance. Moreover, a few educators emphasized the need of an institutional culture that is more encouraging and promotes experimentation and innovation in teaching and learning.

Regarding the implementation of digital technology, public and private universities differed significantly, according to the comparison investigation. While public universities used digital resources more often overall, they also reported increased faculty reluctance. They profited from resources supplied by the government, but bureaucratic obstacles prevented them from using modern technology. Private schools, on the other hand, were more aggressive in implementing cutting-edge instructional strategies, although they faced challenges due to their lower funding and the greater expenses related to digital technology. Additionally, they said that they needed more training and skill development, which is indicative of a lack of institutional support for the incorporation of technology.

Discussion

The results of this study highlight both the progress and challenges in integrating digital and computational technologies in medical education within Khyber Pakhtunkhwa (KPK), Pakistan. The findings align with previous studies conducted in similar contexts, which have also reported an increasing adoption of digital resources and technologies in medical education [15]. For instance, a study found that digital tools significantly enhanced learning outcomes and teaching effectiveness in medical colleges in Punjab, Pakistan. Our study corroborates these findings by showing a high level of perceived benefits among educators and students, particularly in enhancing access to updated resources, improving the visualization of complex concepts, and increasing diagnostic accuracy.

However, the barriers identified in this study, such as limited resources, inadequate training, and resistance to change, echo the challenges reported in other regions [16, 17]. A comparative study on the adoption of digital technologies in medical education in South Asia similarly highlighted resource constraints and a lack of institutional support as significant obstacles [18]. The present study adds to this body of knowledge by providing a detailed analysis of the specific challenges faced by public and private institutions in KPK. Public colleges, despite having higher access to digital resources, faced greater resistance from senior faculty, whereas private colleges struggled with budget constraints and the need for more training [19, 20].

The insights gained from the qualitative component of our research further emphasize the importance of addressing these barriers through strategic interventions. There is a clear need for improved infrastructure, comprehensive training programs, and a shift in institutional culture to promote digital literacy and encourage the adoption of innovative teaching methods. Moreover, our findings suggest that fostering collaboration between public and private institutions could help mitigate some of the resource and training challenges, promoting a more cohesive and supportive environment for digital integration.

Limitations and Upcoming Research: It is important to recognize the many limitations of this research. First off, the fact that the study was limited to a small number of public and private medical institutions in KPK may have limited the results' applicability to other parts of Pakistan or to other educational settings. Second, relying only on self-reported information from surveys and interviews runs the risk of introducing bias since respondents may exaggerate or underestimate how often they use digital technologies and what advantages they see. To get a more thorough knowledge of the integration of digital technologies in medical education, future research endeavors have to contemplate broadening the scope to include a more heterogeneous array of institutions across Pakistan and using mixed-method methodologies. Longitudinal research may also provide light on the long-term effects of computational and digital technologies on healthcare practice and educational results. Ultimately, delving further into the viewpoints of students in addition to academics and administrators would provide a more comprehensive understanding of the potential and difficulties related to digital transformation in medical education.

Conclusion

The substantial potential of digital and computational technology to improve medical education in Khyber Pakhtunkhwa's medical institutions is highlighted by this research. Even if the integration of these technologies has enhanced diagnostic and learning capacities, significant obstacles such a lack of resources, insufficient training, and opposition to change still exist. While commercial organizations are more aggressive but limited by funding, public institutions often have greater access to digital resources but encounter more opposition. To fully reap the advantages of digital transformation in medical education, these issues must be addressed with strategic investments, improved training, and the development of a supportive culture. To better understand these processes and direct the development of efficient policies and practices, future research should concentrate on longer-term, more comprehensive regional studies.

References

1. Garg M, Sethi G, Pandey AK, editors. Transcription and Translation in Health and Disease. Elsevier; 2023 Jan 30.
2. Jin YW. Deconvolution of bulk gene expression profiles to characterize the tumour immune landscape of early onset breast cancer.
3. Antonio M, Francesco L, Luigi A. PREPARATION AND PHYSICO-CHEMICAL CHARACTERIZATION OF KETANSERIN-LOADED LIPOSOMES FOR GLAUCOMA. CAMPOBASSO, DECEMBER 19 2022 thth. 2022 Dec 19:18.
4. Dhar J, Hazra A, Patra R, Kumar V, Subramaniyan V, Kumarasamy V, Mitra AK, Sayed AA, Aleya L, El-Demerdash FM, Almutairi MH. Unveiling Curvularia tuberculata-induced leaf anomalies in Rhododendron ferrugineum: implications in cultural-ecological conservation and harnessing microbial intervention in socio-economic advancement. Frontiers in Microbiology. 2024 Jan 11;14:1280120.
5. Cybil KV, editor. Biopolitics and Healing in a Mass Milieu. Taylor & Francis; 2023 Aug 25.
6. Sharma S, Chauhan J, Mandela Y, Hemavathy AT, Ballari HS. INSIGHTS INTO AGRICULTURE SCIENCES.
7. Bawa R, Chang EH, Audette GF, Diwan A, Faiz SA. Advances in Medical Biochemistry, Genomics, Physiology, and Pathology. Jenny Stanford Publishing; 2021 Dec 22.
8. Fertig B. Metabolism and Medicine: The Metabolic Landscape of Health and Disease (Volume 2). CRC Press; 2022 Jan 31.
9. Bizzarri M, Minini M, Monti N. Revisiting the Concept of Human Disease: Rethinking the Causality Concept in Pathogenesis for Establishing a Different Pharmacological Strategy. Approaching Complex Diseases: Network-Based Pharmacology and Systems Approach in Bio-Medicine. 2020:1-34.
10. Park SO. CONVERGENCE STRATEGY OF DIGITAL LIVESTOCK SYSTEM AND ANIMAL BIOMODELS FOR HUMAN WELLNESS IN FUTURE: A REVIEW. JAPS: Journal of Animal & Plant Sciences. 2024 Jan 1;34(1).
11. Khan M, Spicer J. The evolving landscape of cancer therapeutics. Concepts and Principles of Pharmacology: 100 Years of the Handbook of Experimental Pharmacology. 2019:43-79.
12. Van Hasselt JC, Iyengar R. Systems pharmacology: defining the interactions of drug combinations. Annual review of pharmacology and toxicology. 2019 Jan 6;59(1):21-40.
13. Lim MS, Beyer T, Babayan A, Bergmann M, Brehme M, Buyx A, Czernin J, Egger G, Elenitoba-Johnson KS, Gückel B, Jačan A. Advancing biomarker development through convergent engagement: summary report of the 2nd International danube symposium on biomarker development, molecular imaging and applied diagnostics; March 14–16, 2018; Vienna, Austria. Molecular imaging and biology. 2020 Feb;22:47-65.
14. Giacomini A, Grillo E, Rezzola S, Ribatti D, Rusnati M, Ronca R, Presta M. The FGF/FGFR system in the physiopathology of the prostate gland. Physiological reviews. 2021 Apr 1;101(2):569-610.

15. Alexander SP, Kelly E, Mathie A, Peters JA, Veale EL, Armstrong JF, Faccenda E, Harding SD, Pawson AJ, Southan C, Buneman OP. The concise guide to pharmacology 2021/22: Introduction and other protein targets. British journal of pharmacology. 2021 Oct;178:S1-26.
16. Sergi CM. Digital pathology: the time is now to bridge the gap between medicine and technological singularity. Interactive Multimedia-Multimedia Production and Digital Storytelling. 2019 Feb 13.
17. Hassell LA, Absar SF, Chauhan C, Dintzis S, Farver CF, Fathima S, Glassy EF, Goldstein JA, Gullapalli R, Ho J, Koch LK. Pathology education powered by virtual and digital transformation: now and the future. Archives of Pathology & Laboratory Medicine. 2023 Apr 1;147(4):474-91.
18. Wan S, Coveney PV. Introduction to Computational Biomedicine. InHigh Performance Computing for Drug Discovery and Biomedicine 2023 Sep 14 (pp. 1-13). New York, NY: Springer US.
19. Koivumäki JT, Hoffman J, Maleckar MM, Einevoll GT, Sundnes J. Computational cardiac physiology for new modelers: Origins, foundations, and future. Acta Physiologica. 2022 Oct;236(2):e13865.
20. Pun S, Haney LC, Barrile R. Modelling human physiology on-chip: historical perspectives and future directions. Micromachines. 2021 Oct 15;12(10):1250.