International Journal of Advanced Pharmaceutical Sciences and Research (IJAPSR)
ISSN: 2582-7618 (Online), Volume-5 Issue-5, August 2025

Awareness and Attitudes Toward Implantable Electrical Medical Technologies Among Syrian Medical Students: A Cross-Sectional Survey

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Abstract: ***Background:*** ***Implantable electrical medical technologies (IEMTs) such as pacemakers, cochlear implants, deep brain stimulators, and insulin pumps are transforming modern healthcare by providing innovative diagnostic and therapeutic options. Their successful adoption in clinical settings depends not only on technical availability but also on the readiness, awareness, and attitudes of future healthcare professionals. In Syria, a country facing significant educational and infrastructural challenges, little is known about how medical students perceive and engage with these emerging technologies.*** ***Objective:*** ***This study aimed to evaluate the awareness, attitudes, and perceived readiness of Syrian medical and health sciences students toward IEMTs, and to explore their primary sources of information, perceived benefits, and concerns.*** ***Methods:*** ***A descriptive cross-sectional online survey was conducted in April 2025. A total of 506 undergraduate students and interns from medicine, pharmacy, dentistry, nursing, and biomedical engineering at both public and private universities across Syria participated in the study. The validated Arabic questionnaire comprised 27 items, covering demographic data, knowledge and exposure to IEMTs, attitudes toward their integration into education and clinical practice, and willingness to pursue specialisation in the field. Data were analysed using descriptive statistics and visualised through tables and charts.*** ***Results:*** ***Approximately 66% of respondents reported prior awareness of IEMTs, with cardiac pacemakers and insulin pumps being the most familiar devices among them. Online platforms accounted for 42% of information sources, while only 12% of students had direct interaction with patients using such devices. More than 85% believed that IEMTs are beneficial for healthcare advancement, and 73% supported incorporating them into university curricula. Despite these positive attitudes, students highlighted significant concerns regarding long-term safety, affordability, limited local training facilities, and regulatory gaps. Over 60% expressed interest in pursuing further education or specialization in IEMTs.*** ***Conclusion:*** ***Syrian medical students demonstrate strong enthusiasm and favourable perceptions toward IEMTs, despite limited academic exposure and clinical experience. These findings underscore the urgent need for curriculum reform, enhanced practical training, and policy development to better prepare future healthcare professionals for integrating advanced medical technologies into clinical practice.***

Keywords: Implantable devices, electrical medical technologies, medical education, student attitudes, Syria, and biomedical innovation.

Abbreviations:
IEMTs: Implantable Electrical Medical Technologies

I. INTRODUCTION

Over the past few decades, there has been significant growth in medical technology, which has transformed modern healthcare systems by introducing new methods for diagnosis, monitoring, and treatment [1]. One of the most notable changes within healthcare systems is the increasing availability of implantable electrical medical devices, which have evolved from experimental devices to clinically proven, life-saving implants. These implantable devices, including cardiac pacemakers, neurostimulators, cochlear implants, and continuous glucose monitors, have become vital surgically invasive devices that significantly enhance the quality of life for millions worldwide [2]. They are instrumental in the treatment of chronic and neurologically complicated disorders such as cardiac arrhythmias, epilepsy, Parkinson's disease, and diabetes mellitus. Unlike traditional medication regimens, these devices, through automation and precision, deliver specific therapeutic actions, making them noteworthy substitutes or additions to medication [3].

The efficient healthcare system does not function due to the presence of advanced devices or scientific innovations. Alongside scientific innovation, there exists a prerequisite for healthcare systems integration: an ecosystem that is trained, informed, and receptive. Implantable technologies are a fundamental aspect that medical students must thoroughly study during their formative educational years, as they will be the future caregivers and decision-makers of our society [4]. Technologically advanced nations have conducted studies focusing on the integration of medical technology in preclinical and clinical training, which has enhanced preparedness, reduced patient care hesitance, and improved the healthcare system [5].

The case of Syria is emblematic of a developing country confronted with multifaceted challenges. While the world increasingly depends on sophisticated healthcare systems, the integration of modern biomedical technologies into Syrian

Manuscript received on 19 July 2025 | First Revised Manuscript received on 28 July 2025 | Second Revised Manuscript received on 05 August 2025 | Manuscript Accepted on 15 August 2025 | Manuscript published on 30 August 2025.

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medical education and practice is profoundly lacking [6]. The healthcare system is hindered by severe economic sanctions, infrastructural damage, ongoing political turmoil, and limited opportunities for technological development. Additionally, many Syrian medical universities do not offer classes in bioelectronics, biomedical engineering, or therapeutic devices, and lack formal educational pathways in these crucial fields [7].

Social media is helping promote global innovations, including new online courses and academic materials, especially for younger people. Syrian medical students are not disconnected from these global issues. Several of them exhibit curiosity, self-motivation, and a readiness to adopt new technologies—despite having scant access to extracurricular training or institutional backing [8].

It also seeks to determine important socio-educational and political issues that could limit the integration and safe use of these innovations within the Syrian framework. The study's main objective is to evaluate the scope of impressions, attitudes, and readiness responsible for implantable electrical medical technology systems among medical and health sciences students in Syria [9]. Additionally, it seeks to explore students' knowledge and their sources of information, their perceptions of unprecedented benefits and risks, and their overall interest in pursuing specialization in the subject matter [10].

By investigating these dimensions, this research contributes to a growing body of regional literature that seeks to align medical education in the Middle East with global standards. It also provides valuable insights for policy makers, curriculum designers, and academic leaders who aim to build a future-ready generation of clinicians capable of integrating emerging technologies into patient care [11].

II. STUDY OVERVIEW

The focus of this research is to explore the perceptions that Syrian students studying medicine, pharmacy, dentistry, nursing, and biomedical engineering hold regarding implantable electrical medical technologies (IEMTs), which are a cornerstone of contemporary innovation in the healthcare sector and hold the promise to alter the global medical practice landscape. Examples of IEMTs include cardiac pacemakers, neurostimulators, and insulin pumps, which embody a vital link between medicine, engineering, and digital health.

This study aims to measure prior exposure, awareness, attitudes towards, and perceptions of the benefits, risks, and acceptability of such technologies among students. It also assesses how students intellectually gauge their readiness to engage with the technologies in patient care, research, or through public health work.

In addition to individual awareness and personal attitudes, the study explores demographic and institutional variables—including academic discipline, year of study, type of university (public vs. private), and geographic distribution across Syrian regions. These variables were analysed to identify patterns that may reflect more profound disparities in access to quality education or exposure to biomedical innovation.

A significant focus of this research is to evaluate students' expectations from the healthcare system, particularly about:

- Access and availability of implantable technologies.
- Affordability and socioeconomic equity in their implementation.
- Perceived safety and biocompatibility.
- The readiness of regulatory and clinical infrastructure to adopt these technologies responsibly.

Fulfilling these distinct components of the study reveals not only the contemporary educational and systemic flaws, but also offers solutions concerning the curriculum development and national capacity building. It is designed for interdisciplinary curriculum development, enhancing academic and industrial connections, and discussions on policy changes that aim to transform the medical education framework in Syria.

Firstly, the study situates itself within a broader international scope, envisioning physicians, pharmacists, and health professionals as trained specialists capable of functioning in an environment heavily influenced by technology in all aspects of healthcare.

III. MATERIALS AND METHODS

A. Study Design

This study was developed as a descriptive, cross-sectional survey with the specific objective of assessing the awareness, attitudes, and self-assessed preparedness of Syrian medical students concerning the use of implantable electrical medical technologies (IEMTs). An online, structured questionnaire was created and disseminated through Google Forms, enabling a broad reach and ease of access to diverse academic institutions.

B. Survey Instrument

The survey instrument comprised 27 items, meticulously organized into three key sections:

- Demographic data - age, gender, university name, university type (public or private), academic discipline, and study year.
- Knowledge and exposure: This section examined previous knowledge of IEMTs such as pacemakers, insulin pumps, cochlear implants, and neurostimulators, and their primary information sources (academic curricula, social media, peers).
- Attitudes and professional outlooks – assessing essential questions about the perceived usefulness and safety of the technologies, anticipated future roles, ethical implications, and willingness to specialize or endorse the technologies in future practice.

The questionnaire was developed in Arabic and validated by a panel of two academic researchers in pharmacy and biomedical sciences for content relevance and clarity. A sample of 10 students reviewed a pilot version to ensure comprehension, resulting in minor linguistic adjustments before its full deployment.

C. Participants and Sampling

Five hundred six respondents completed the survey. All participants were enrolled in an undergraduate or internship program in a medical-related field, such as medicine, pharmacy, dentistry, nursing, or biomedical engineering, at both public and private universities across Syria. The sampling method was non-probabilistic convenience sampling based on self-selection. Nonetheless, the sample achieved a reasonable level of geographic and institutional diversity, albeit with some substantial concentrations from universities in Latakia (Tishreen University), Damascus, Aleppo, Homs, and several private schools.

Pharmacy students comprised the majority of respondents, and a sizable proportion attended public universities. The respondents spanned from first-year to intern, which allowed the study to gather insights at various levels of academic and developmental engagement.

D. Data Collection Procedures

Information was gathered over two weeks in April 2025. The survey link was shared through social media associated with academics, online discussion boards tied to the university, as well as WhatsApp and Telegram. No identifiable information was collected, as participation was anonymous and voluntary. Respondents were provided with an informed consent statement detailing the study's purpose, confidentiality, and publication plans prior to participating in the survey. Participants were only those who clicked "I consent." Thus, only those who accepted the consent terms were permitted to complete the questionnaire.

E. Data Analysis

The gathered responses were analyzed and cleaned in Microsoft Excel 365. All categorical variables were summarized using absolute frequencies and descriptive statistics. If relevant, some insights were compared by gender, field of study, year of study, and type of university. To highlight significant findings related to prior knowledge, attitudes, and perceived challenges, relevant dimensions were visually represented using bar and pie charts.

Globally, trends in medical education and technological literacy were compared to the baseline infrastructures in Syria to inform the interpretations. The academic committee of the authors' affiliated institution provided approval for the study design and ensured compliance with ethical research standards for the anonymised surveys, which posed minimal risk.

IV. RESULTS

A. Demographics

Of the total 506 participants, approximately 65% were pharmacy students, 19% were studying medicine, and smaller percentages came from dentistry, nursing, and biomedical engineering. Public university attendance was significantly higher, at 72%, compared to 28% from private institutions. Tishreen University and Damascus University had the highest representation, while Qalamoun, Al-Andalus, and Al-Hawash Universities, along with some private universities from Aleppo and Homs, contributed to the representation.

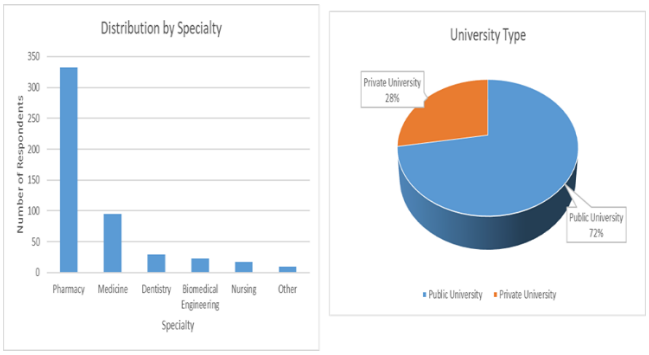
The majority of the respondents were female, comprising approximately 68% of the total, and they were primarily between 20 and 24 years old.

Demographic information of the participants is presented in Table 1. Responses from other participants at the remaining universities are not included in the table, as they did not meet the minimum representation criteria.

Additionally, the distribution of participants by field of study and type of university attended is illustrated in Figure 1.

Table 1: Demographic Characteristics of the Study Participants

Variable	Category	Count	(%)
Age	25	75	14.8
	24	66	13.0
	26	58	11.5
	27	53	10.5
	22	48	9.5
	23	41	8.1
	28	39	7.7
	29	26	5.1
	21	22	4.3
	30	16	3.2
	20	14	2.8
	31	10	2.0
	33	7	1.4
	Missing	6	1.2
	35	5	1.0
Specialty	Pharmacy	332	65.6
	Medicine	95	18.8
	Dentistry	29	5.7
	Biomedical Engineering	23	4.5
	Nursing	17	3.4
	Other	10	2.0
University Type	Public University	366	72.3
	Private University	140	27.7
University Name	Tishreen University	131	25.9
	Damascus University	97	19.2
	Qalamoun University	39	7.7
	Al-Andalus University	35	6.9
	Al-Hawash University	27	5.3
	Aleppo University	21	4.2
	Yarmouk Private University	20	4.0
	Arab International University	17	3.4
	AL-Furat University	13	2.6
	Hama University	10	2.0



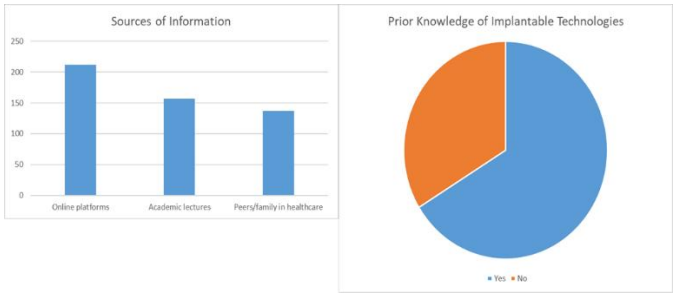
[Fig.1 :Distribution of Respondents by University Type and Speciality]

B. Knowledge and Exposure

Approximately 66% of students reported being aware of implantable electrical medical

technologies. More frequently identified devices included cardiac pacemakers (85%), insulin pumps (72%), cochlear implants (49%), and deep brain stimulators (39%). The primary sources of information were online platforms (42%), academic lectures (31%), and healthcare professionals among peers or relatives (27%). Only 12% had firsthand interaction with a patient or family member using these devices. Interestingly, approximately 34% of students were unaware of newer devices, such as vagus nerve stimulators and brain-computer interfaces.

As shown in Figure 2, the participants' prior knowledge of the technologies and their primary information sources are illustrated along with levels of awareness.

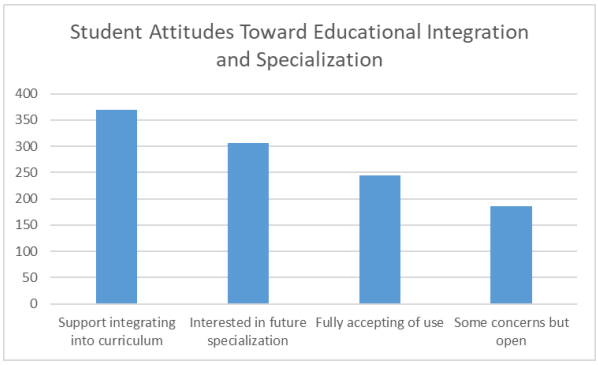


[Fig.2: Prior Knowledge and Sources of Information about Implantable Medical Technologies]

C. Perceptions and Attitudes

A large majority (85.4%) considered implantable technologies as transformative for the future of medicine. Approximately 73% supported incorporating these technologies into university curricula, and 60.5% expressed interest in future specialisation or career paths involving them. When asked about personal acceptance—either as a physician recommending them or as a patient receiving them—48.2% were fully accepting while 36.7% had reservations. Moreover, 78.9% of students believed that their academic institutions provide insufficient exposure to these technologies.

Figure 3 presents an overview of students' attitudes regarding the integration of implantable medical technologies into academic curricula and their interest in future specialization.



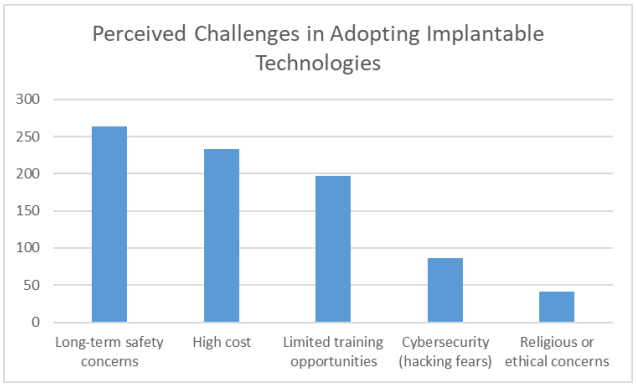
[Fig.3: Students' Attitudes Toward Educational Integration and Future Specialization]

D. Concerns and Challenges

The following reflects the most commonly cited reasons for hesitancy towards the use of implantable technologies (Figure 4).

- Long-term safety and biocompatibility – 52%
- Affordability and availability of funding – 46%
- Limited local training facilities – 39%
- Cybersecurity vulnerabilities (hacking or malfunction) – 17%
- Religious or ethical objections – 8%

Furthermore, an overwhelming majority, 70.2% of respondents, opined that these technologies would likely supplant some traditional medicine in the future, particularly in cardiology and endocrinology. At the same time, 63.8% voiced scepticism about safety and approval regulations in the Syrian context.



[Fig.4: Perceived Challenges in Adopting Implantable Technologies]

V. DISCUSSION

The results of this study confirm the generally positive attitudes of Syrian medical students toward the integration of implantable electrical medical technologies (IEMTs), viewing them as a core component of future healthcare systems [12]. A significant portion of the respondents possessed both foundational knowledge and a substantial interest in these technologies, especially in well-known and clinically established devices such as cardiac pacemakers and insulin pumps. This suggests
that even within a resource-constrained setting, students are actively engaging with global medical developments, primarily through self-education and online platforms [13].

A strong parallel can be drawn with the study conducted in India by Singh et al. (2022), which also reported an overwhelming curiosity and perceived value of implantable devices among undergraduate medical students, regardless of scant curricular exposure. In a similar vein, a cross-sectional study conducted in Jordan by Al-Shudifat et al. (2020) noted a moderate level of awareness of cardiac devices, coupled with a strong willingness among students to advocate for enhanced curricular content related to these devices [14].

Nonetheless, this excitement is not matched by institutional preparedness. Approximately 80 per cent of students from our sample reported insufficient academic exposure to IEMTs, which underscores a critical curricular shortcoming. A recent study in Nigeria corroborates this disconnect (Ibrahim et al., 2021), where student interest in certain medical technologies was not matched with the academic coverage given to those technologies. These

gaps, prevalent in numerous developing nations, highlight a persistent struggle to tailor medical education to the rapidly evolving biomedical engineering landscape [15].

The acute dependence on online resources as the primary, and often the only, source of information far exceeds that of traditional academic lectures, pointing to an immediate need to formalise education in biomedical engineering. While this independent initiative showcases student resilience and flexibility, it simultaneously poses challenges to the rigour of the information being used and the understanding that learners have. Similar observations were recorded in studies from Egypt (Hassan et al., 2021) and Malaysia (Chong et al., 2020), as both countries stressed the absence of formal structure as a significant risk of unregulated technological learning [16].

Perhaps the most significant finding in our research is that more than 60% of participants showed interest in furthering their education or specializing in implantable technologies.4 This indicates a broad shift toward interdisciplinary, technology-oriented healthcare, in which future practitioners will not be mere operators of instruments but will focus on innovation, evaluation, and developmental activities. The findings are consistent with a survey from Turkey (Demirci et al., 2021) that highlighted student enthusiasm when exposed to biotechnology-based clinical modules [17].

However, the data also underscore challenges and ethical concerns. Students cited safety, biocompatibility, cost, and cybersecurity risks as concerns, all of which are well-documented in the global literature. A systematic review conducted by Mishra & Patel (2021) highlighted that even among high-income countries, healthcare workers are highly sceptical about the invasiveness and long-term consequences of bioelectronic implants. It is noteworthy that while Syrian students raised concern regarding ethical and religious aspects, in comparison to studies from Saudi Arabia and Pakistan, where cultural and spiritual elements were more dominant in providing resistance to implantable technologies, this was much less pronounced [18].

Moreover, students raised doubts about whether national policies or any form of oversight existed regarding Syria's regulatory framework, citing its lack of infrastructure. This concern aligns with observations made in other conflict-affected or economically challenged regions, including Iraq and Lebanon, where the implementation of health technologies is often burdened by weak governance and policy fragmentation [19].

The lack of clinical exposure among students is a significant area that warrants attention. Reflection on clinical learning revealed that few participants had the opportunity to engage with patients who used these devices, indicating a gap in clinical knowledge and experience. Almost all South Asian students, as noted by Sharma et al. (2020), express similar concerns, and the authors propose integrating simulation, interdisciplinary workshops, and case-based learning to bridge the theory-practice gap (Sharma et al., 2020) [20].

Most importantly, the considerable enthusiasm for change expressed by respondents presents a unique chance. With synergistic relationships established with industrial and academic stakeholders, Syrian institutions can overcome systemic challenges by developing curricula that incorporate technology-specific modules, supporting faculty training, and preparing a healthcare workforce for the future [21].

As discussed, the balance between encouraging interest and awareness, alongside the need for medical educational reform, revealed in the study is particularly salient for regions that are politically or economically restricted. The relationship, or lack thereof, with other countries underscores the need for tailored approaches to ensure that medical graduates from Syria are well-versed in modern healthcare and can adapt to emerging technologies with confidence, ethics, and competence [22].

VI. CONCLUSION

This study highlights the generally positive attitudes of Syrian medical students toward the integration of implantable electrical medical technologies (IEMTs) into future healthcare systems. The findings emphasize the importance of developing educational strategies and policies that facilitate the adoption of advanced biomedical technologies in medical curricula. By addressing the socio-educational and infrastructural challenges identified, stakeholders can better prepare future physicians for a rapidly evolving medical landscape. Further research is recommended to explore specific training modules, long-term implementation outcomes, and cross-regional comparisons, thereby strengthening these preliminary findings.

LIMITATIONS

Although it provides essential information regarding the awareness and attitudes of Syrian medical students toward implantable electrical medical technologies, this study has certain limitations:

- The implementation of an online survey employing a self-reporting mechanism poses risks, including response bias, particularly social desirability bias, in which respondents tailor their answers based on what they believe to be more favourable, instead of reflecting their genuine viewpoints or actual knowledge.
- The sample included an unusually high proportion of pharmacy students, which may affect the extent to which the findings apply to students from other fields such as medicine, biomedical engineering, or surgery. Their perspectives—especially those related to implantation or technical integration—may be underrepresented.
- The lack of employment of validated scales as measuring tools for the student's level of clinical exposure or practical competence about implantable technologies may limit accuracy in interpreting the student's actual level of information or skill.
- Because of the cross-sectional design, the study offers a snapshot in time, so academic exposure and attitudes cannot be causally linked. To evaluate the impact of education and clinical training on students' perceptions over time, longitudinal studies would be necessary.

- The geographical representation of participants was skewed as the majority of them came from the coastal and central regions of Syria. Students from the northern, eastern, or more rural areas of the country may have differing levels of access to educational, infrastructural, and clinical resources, which were not captured by this survey.

RECOMMENDATIONS

- Integrate optional elective courses and certifications within curricula of health sciences on implantable medical technologies.
- Organise multidisciplinary workshops that include the faculties of medicine, pharmacy, and engineering.
- Set up innovation and research hubs in medical technology led by students.
- Partner with foreign universities to provide webinars and virtual laboratory sessions on electrical biomedical systems.
- Foster discussions at the national level on the adoption of such technologies into the Syrian healthcare system.
- Engage practising clinicians and engineers as co-lecturers in some modules to provide practical perspectives.
- Conduct public awareness campaigns on the advantages and safety of medical implants.

ACKNOWLEDGEMENT

The authors extend their appreciation to the students from the faculties of Medicine, Pharmacy, Dentistry, Nursing, Biomedical Engineering, and other enrolled disciplines, as well as to the postgraduate trainees and medical residents from Tishreen University Hospital, for their participation and collaborative efforts during this research.

The authors appreciate the university's academic groups and administrative staff who assisted with the logistics of data collection and advocacy for the research initiative.

DECLARATION STATEMENT

The authors state that there is no conflict of interest concerning the publication of this study. All participation was voluntary, and data collection was conducted anonymously in compliance with ethical research standards. No ethical approval was necessary because the study was non-interventional and anonymous. After aggregating input from all authors, I must verify the accuracy of the following information as the article's author.

- **Conflicts of Interest/ Competing Interests:** Based on my understanding, this article has no conflicts of interest.
- **Funding Support:** This article has not been funded by any organizations or agencies. This independence ensures that the research is conducted with objectivity and without any external influence.
- **Ethical Approval and Consent to Participate:** The content of this article does not necessitate ethical approval or consent to participate with supporting documentation.
- **Data Access Statement and Material Availability:** The adequate resources of this article are publicly accessible.
- **Author's Contributions:** Each author has individually contributed to the article. Aya Kourkmaz and Aya Kazan prepared and wrote the graduation project, designed the questionnaire, and supervised the project. Zein Al-Abideen Douba wrote this article, distributed the questionnaire to physicians and pharmacists, and performed the statistical analysis of the results. Mohammad Haroun provided overall supervision of the project.

REFERENCES

1. Sheng H, Zhang X, Liang J, Shao M, Xie E, Yu C, et al. Recent Advances in Energy Solutions for Implantable Bioelectronics. *Advanced Healthcare Materials.* 2021;10(17):2100199. DOI: https://doi.org/10.1002/adhm.202100199
2. Arjmand B, Payab M, Goodarzi P. *Biomedical product development: bench to bedside.* Springer; 2020. DOI: https://doi.org/10.1007/978-3-030-35626-2
3. Stanslaski S, Herron J, Chouinard T, Bourget D, Isaacson B, Kremen V, et al. A chronically implantable neural coprocessor for investigating the treatment of neurological disorders. *IEEE Trans Biomed Circuits Syst.* 2018;12(6):1230-45. https://ieeexplore.ieee.org/document/8550817
4. Moran J, Briscoe G, Peglow S. Current technology in advancing medical education: perspectives for learning and providing care. *Academic Psychiatry.* 2018;42(6):796-9. DOI: https://doi.org/10.1007/s40596-018-0920-2
5. Alrashed FA, Ahmad T, Almurdi MM, Alderaa AA, Alhammad SA, Serajuddin M, et al. Incorporating technology adoption in medical education: a qualitative study of medical students' perspectives. *Adv Med Educ Pract.* 2024;15:615-25. DOI: https://doi.org/10.2147/AMEP.S410964
6. Aamir J, Ali SM, Boulos MNK, Anjum N, Ishaq M. Enablers and inhibitors: a review of mHealth adoption in low- and middle-income countries. *Health Policy Technol.* 2018;7(1):88-97. DOI: https://doi.org/10.1016/j.hlpt.2017.12.010
7. Alfakhry G, Naeem A, AboHajar MB, Alfakhry A, Mohandes AF, Ali I, et al. Revealing the significant shortcomings in the learning environment at the three largest medical schools in Syria: what's next? *BMC Med Educ.* 2023;23(1):2. DOI: https://doi.org/10.1186/s12909-022-04032-7
8. Das TM, Kaur G, Nematollahi S, Ambinder D, Shafer K, Sulistio M, et al. Medical education in the digital Era: a new paradigm for acquiring knowledge and building communities. *JACC.* 2022;100031. DOI: https://doi.org/10.1016/j.jacc.2022.100031
9. Masoumian Hosseini ST, Qayumi K, Pourabbasi A, Haghighi E, Sabet B, Koohpaei A, et al. Are we ready to integrate modern technologies into the medical curriculum for students? A systematic review. *Discover Education.* 2025;4(1):114. DOI: https://doi.org/10.1007/s44217-024-00092-7
10. Peprah P, Abalo EM, Agyemang-Duah W, Gyasi RM, Reforce O, Nyonyo J, et al. Knowledge, Attitudes, and Use of mHealth Technology Among Students in Ghana. *BMC Med Inform Decis Mak.* 2019;19(1):220. DOI: https://doi.org/10.1186/s12911-019-0939-3
11. Boillat T, Otaki F, Baghestani A, Zarnegar L, Kellett C. A landscape analysis of digital health technology in medical schools. *BMC Med Educ.* 2024;24(1):1011. DOI: https://doi.org/10.1186/s12909-024-04887-x
12. Allam AH, Eltewacy NK, Alabdallat YJ, Owais TA, Salman S, Ebada MA. Knowledge, Attitude, and Perception of Arab Medical Students Towards AI in Medicine and Radiology. *European Radiology.* 2024;34(7):1-14. DOI: https://doi.org/10.1007/s00330-024-09763-3
13. Alameddine M, Bou-Karroum K, Hijazi MA, El-Jardali F. Exploring the attitudes of medical students toward robotic surgery and advanced

surgical technologies: a cross-sectional study. *BMC Med Educ.* 2022;22(1):415. DOI: https://doi.org/10.1186/s12909-022-03548-7
14. Singh A, Jadon RS, Baitha U, Sethi P, Kaur H, Kumar A, et al. Indian Medical Student Perspectives on the Online Mode of Education. *J Fam Med Prim Care.* 2022;11(7):3915-22. DOI: https://doi.org/10.4103/jfmpc.jfmpc_1008_21
15. Oluwadiya KS, Adeoti AO, Agodirin SO, Nottidge TE, Usman MI, Gali MB, et al. Exploring artificial intelligence in the Nigerian medical educational space. *Niger Postgrad Med J.* 2023;30(4):285-92. https://journals.lww.com/npmj/Fulltext/2023/30040/Exploring_artificial_intelligence_in_the_Nigerian.11.aspx
16. Mortagy M, Abdelhameed A, Sexton P, Olken M, Hegazy MT, Gawad MA, et al. Online Medical Education in Egypt during COVID-19. *BMC Med Educ.* 2022;22(1):218. DOI: https://doi.org/10.1186/s12909-022-03273-7
17. Mokresh ME, Muvaffak E, Kahya M, Torun P, 4 CBMFM. Knowledge, Attitudes, and Barriers toward Research among Medical Students. *Med Sci Educ.* 2024;34(2):387-95. DOI: https://doi.org/10.1007/s40670-024-01829-y
18. Packer S, Mercado N, Haridat A. Bioelectronic medicine—ethical concerns. *Cold Spring Harb Perspect Med.* 2019;9(10):a034363. DOI: https://doi.org/10.1101/cshperspect.a034363
19. Bogale B, Scambler S, Mohd Khairuddin AN, Gallagher JE. Health System Strengthening in Fragile and Conflict-Affected States. *PLoS One.* 2024;19(6):e0305234. DOI: https://doi.org/10.1371/journal.pone.0305234
20. Okuda Y, Bond W, Bonfante G, McLaughlin S, Spillane L. Simulation-based education: what every educator should know. *Medical Education.* 2020;54(1):16-23. DOI: https://doi.org/10.1111/medu.13874
21. Shelton P, Corral I, Kyle B. Advancements in undergraduate medical education: meeting the challenges of an evolving world of education, healthcare, and technology. *Psychiatric Quarterly.* 2017;88(2):225-34. DOI: https://doi.org/10.1007/s11126-016-9471-x
22. Chang Chan AYC, van Leeuwen M, Custers E, Bleys R, Ten Cate O. Anatomy education in low-resourced countries. *Medical Teacher.* 2025;47(5):883-93. DOI: https://doi.org/10.1080/0142159X.2024.2303246

AUTHOR'S PROFILE

Aya Kourkmaz, born on 6 June 2002 in Latakia, Syria, is a fifth-year pharmacy student at Tishreen University. She achieved second place in her class during her fourth year, showcasing her outstanding academic achievement and dedication. Aya has a keen interest in pharmacology, drug development, and innovative medical technologies, and she has actively participated in research projects aimed at improving healthcare education and practices. She is passionate about scientific writing, problem-solving, and developing skills that will support her future postgraduate studies. Aya aspires to contribute to the development of the pharmaceutical field in her country and beyond.

Aya Kazan, born on August 22, 2002, in Latakia, Syria, is currently a fifth-year student in the pharmacy program at Tishreen University. She ranked fifth in her class during her fourth year, a testament to her strong academic dedication and consistent performance. Aya has demonstrated significant interest in pharmacology, clinical pharmacy, and biomedical technologies. Her enthusiasm for scientific research led her to contribute to projects that explore innovative healthcare solutions. As an aspiring pharmacist, Aya is dedicated to expanding her knowledge in pharmaceutical sciences and plans to pursue postgraduate studies in the future. She values teamwork, research ethics, and continuous learning, which drive her academic and professional aspirations.

Dr. Zein Al-Abideen Douba is an accomplished Syrian pharmacist and the corresponding author of this article. He holds a Master's degree in Laboratory Diagnostics from the Faculty of Pharmacy at Tishreen University, where he graduated with distinction. Over the years, Dr. Douba has established a remarkable academic and research profile, serving as both author and co-author on numerous peer-reviewed scientific publications in reputable international journals, significantly advancing knowledge in his field. In 2024, Dr. Douba proudly participated in the Conference of Syrian Expatriate Researchers, where he showcased his expertise and contributed to fostering international scientific collaboration. Renowned for his broad experience, he currently serves as an editor and reviewer for several prestigious journals, including Cureus, Open Access Journal of Asian Youth (OAJAY), and the Asian Pacific Journal, further enhancing his proficiency in research methodologies, biomedical writing, and adherence to high ethical publication standards. Beyond his research, Dr. Douba has actively guided and supported numerous pharmacy students in completing their graduation projects, particularly those involving survey-based studies among cancer patients or practising physicians. His mentorship has contributed to the successful completion and publication of many student-led research projects. His primary research interests include oncology biomarkers, implantable bioelectronic devices, and the integration of cutting-edge technologies into modern medical curricula. Fluent in Arabic and English and proficient in Japanese, Dr. Douba is driven by a strong commitment to improving healthcare in resource-limited environments. He consistently bridges the gap between academic research and clinical practice. He remains deeply passionate about mentoring early-career researchers and fostering collaborative projects that aim to develop innovative diagnostic and therapeutic solutions with tangible impacts on patient care.

Dr. Mohammad Haroun is a highly distinguished pharmaceutical scientist and academic leader with decades of experience in pharmaceutical sciences, pharmacovigilance, and higher education management. He earned his Ph.D. in Pharmaceutical Sciences (Pharmacovigilance) from Joseph Fourier University, France, in 2007. His academic journey also includes a DEA in Molecular Chemistry (2003), a DU in Drug and Equipment Sterilization from Paris V University (2004), and an AEU in Quality, Standards, and Regulatory Frameworks from Claude Bernard University (2007). He obtained his initial degree in Pharmacy and Pharmaceutical Chemistry from Tishreen University in Syria in 1997, laying the foundation for his outstanding career. Dr. Haroun has held numerous prominent administrative and academic positions. He currently serves as the Dean of the Faculty of Pharmacy at Tishreen University (2021–present). Previously, he served as Dean of the Faculty of Pharmacy at Al-Manara University (2019–2021) and Al-Andalus University for Medical Sciences (2015–2019). He also served as Vice-Dean for Administrative and Student Affairs (2011–2015) and Head of the Department of Pharmaceutical Chemistry and Pharmacovigilance (2010–2013) at Tishreen University. Additionally, he was the Director of the Quality Assurance Unit and Seminar Coordinator (2011–2012), further demonstrating his commitment to academic excellence and institutional development. Throughout his career, Dr. Haroun has authored and co-authored over 35 scientific publications in national and international journals, as well as written two academic books. He has supervised numerous master's and doctoral theses, mentoring future generations of pharmacists and researchers. His research interests focus on pharmaceutical quality control, pharmacovigilance, and regulatory affairs, contributing significantly to the improvement of drug safety and standards. Dr. Haroun is an active member of the Advisory Board of the Arab Journal of Pharmaceutical Sciences and participates in specialized committees of the Arab Board of Pharmacy. Fluent in Arabic, French, and English, he is recognized for his exceptional leadership, scholarly achievements, and dedication to advancing pharmaceutical education and practice in the region.