

Original article

Knowledge, Attitude, and Practice about Nanomedicine in Drug Delivery Systems among Medical Students in Southern Libya

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Abstract

Nanomedicine is an emerging approach in drug delivery with the potential to improve therapeutic efficacy, targeted delivery, and patient safety. This study assessed knowledge, attitudes, and practices (KAP) regarding nanomedicine among medical students in Southern Libya. A cross-sectional questionnaire-based study was conducted among medical students from health faculties in Southern Libya. Of 150 distributed questionnaires, 137 were returned (91.3% response rate). Data on sociodemographic characteristics, exposure, knowledge, attitudes, and practices were analysed using descriptive statistics and chi-square tests. Most participants were female (86.9%) and aged 21–23 years (44.5%). Academic exposure to nanomedicine was limited, with 93.4% having not attended related lectures or courses. Overall, 73.7% demonstrated good knowledge, while 51.1% had a negative attitude and 81.8% showed poor practice. Knowledge was good regarding nanomedicine definitions, nanoparticle applications, and nanocarriers, but awareness of clinical translation challenges was limited. No significant associations were found between sociodemographic characteristics and KAP levels ($p > 0.05$). Medical students demonstrated good knowledge but limited practical engagement and relatively negative attitudes toward nanomedicine. Incorporating nanomedicine into undergraduate curricula and increasing research opportunities may improve students' preparedness for its future applications in healthcare.

Keywords. Nanomedicine; Drug Delivery Systems; Knowledge; Attitude; Practice; Medical Students; Nanoparticles; Nanocarriers; Southern Libya.

Introduction

Nanomedicine is an interdisciplinary field that applies nanotechnology to the prevention, diagnosis, and treatment of disease. In pharmaceutical sciences, its most important applications include the development of nanoscale drug-delivery systems designed to improve drug solubility, stability, bioavailability, therapeutic efficacy, and tissue-specific targeting. Nanocarriers such as liposomes, polymeric nanoparticles, dendrimers, micelles, and solid lipid nanoparticles can provide controlled or sustained drug release and may reduce systemic toxicity and other limitations associated with conventional drug-delivery approaches [1-3]. Nanotechnology-based drug-delivery systems have demonstrated potential in several therapeutic areas, including cancer, infectious diseases, neurological disorders, gene therapy, and vaccine delivery. Their ability to modify drug distribution, enhance cellular uptake, and facilitate delivery across biological barriers has contributed to growing interest in their clinical application and their potential role in personalised medicine [2,3]. Pharmacists have an important role in the safe and effective use of nanomedicine. As medication experts, they may contribute to the development, formulation, preparation, dispensing, storage, administration, monitoring, and pharmacovigilance of nanoparticle-based medicines. Pharmacists also provide patient counselling and participate in multidisciplinary decisions concerning the appropriate use of nanomedicine and related products [3]. The increasing introduction of nanomedicine into healthcare highlights the importance of adequate knowledge and education among future healthcare professionals. Medical and pharmacy students will have important roles in the future use, monitoring, and patient education associated with nanotechnology-based therapies. However, educational exposure and awareness of nanomedicine may remain limited in some healthcare settings. Assessing students' knowledge, attitudes, and practices (KAP) toward nanomedicine and its applications in drug delivery can therefore help identify educational needs and inform curriculum development. Such assessment may contribute to improving students' preparedness for the safe and rational use of nanomedicine in future clinical practice [4]. Accordingly, the present study aims to assess the knowledge, attitudes, and practices of medical students regarding nanomedicine, with particular emphasis on its applications in drug-delivery systems. The findings may provide baseline information for identifying educational gaps and developing appropriate educational strategies in this emerging area of pharmaceutical and medical sciences.

Materials and Methods

A cross-sectional questionnaire-based study was conducted from January to March 2026, carried out by senior pharmacy students at the Faculty of Pharmacy, among students of Medicine, Pharmacy, Dentistry, and Medical Technology students at Sebha University, Libya. The questionnaire was adapted from a previous Iraqi study [5] and modified to assess knowledge, attitudes, and practices (KAP) regarding nanomedicine in drug delivery systems. The questionnaire consisted of 27 multiple-choice items divided into four sections: sociodemographic characteristics, knowledge, attitude, and practice. Multiple-choice questions were used to facilitate completion and obtain standardised responses. A total of 150 questionnaires were distributed to eligible participants. Students were given sufficient time to read and complete the questionnaire voluntarily after providing informed consent. Data were analysed using SPSS version 27. Categorical variables were summarised as frequencies and percentages. The chi-square test (χ^2) was used to examine associations

between sociodemographic characteristics and knowledge, attitude, and practice levels. A p-value <0.05 was considered statistically significant. Undergraduate students aged ≥ 18 years who were enrolled at the Faculty of Pharmacy, Sebha University, and willing to participate were included. Students who refused participation, did not provide informed consent, submitted incomplete questionnaires, or were unavailable during data collection were excluded.

Results

Of the 150 questionnaires distributed, 137 were returned, yielding a response rate of 91.3%. Participants were aged 18–38 years, with most aged 21–23 years (44.5%), followed by 24–26 years (35.8%). The sample was predominantly female (86.9%). Regarding academic level, fourth-year students represented the largest group (32.8%), followed by sixth-year (21.2%) and third-year students (16.8%). By faculty, Medicine students comprised the largest proportion (32.8%), followed by Pharmacy (29.2%), Medical Technology (24.8%), and Dentistry (13.1%) (Table 1).

Table 1. Sociodemographic Characteristics of Medical Students

Variable	Category	Frequency	Percentage (%)
Age (years)	18–20	12	8.8
	21–23	61	44.5
	24–26	49	35.8
	≥ 27	15	10.9
Gender	Male	18	13.1
	Female	119	86.9
Academic Year	1st	10	7.3
	2nd	12	8.8
	3rd	23	16.8
	4th	45	32.8
	5th	18	13.1
	6th	29	21.2
Faculty	Medicine	45	32.8
	Pharmacy	40	29.2
	Dentistry	18	13.1
	Medical Technology	34	24.8

Most students (93.4%) reported no prior exposure to lectures or courses on nanomedicine, and 89.1% had not read related scientific articles or textbooks. The main sources of information were websites (20.4%) and social media (19.7%), followed by lectures (17.5%). Textbooks (8.0%), scientific journals (5.1%), workshops/conferences (4.4%), and peers (1.5%) were less frequently reported, while 23.4% relied on other sources (Table 2). Most participants demonstrated a moderate level of knowledge about nanomedicine. Correct responses were reported for the definition of nanomedicine (67.9%), nanoparticle types used in drug delivery (73.0%), improved drug solubility and bioavailability through nanocarriers (82.5%), and nanoparticle safety (70.1%).

Table 2. Exposure to and Sources of Information about Nanomedicine

Variable	Category	Frequency	Percentage (%)
Attended lecture/course on nanomedicine	Yes	9	6.6
	No	128	93.4
Read scientific articles/textbooks on nanomedicine	Yes	15	10.9
	No	122	89.1
Source(s) of information	Lectures	24	17.5
	Textbooks	11	8.0
	Scientific journals	7	5.1
	Social media	27	19.7
	Websites	28	20.4
	Peers	2	1.5
	Workshops/conferences	6	4.4
	Other	32	23.4

Knowledge of the EPR effect was 65.0%, while only 40.9% recognised key challenges in clinical translation. Only 27.0% correctly identified telepathic administration as a non-applicable route. Regarding regulation, 73.0% recognised the role of national regulatory authorities, whereas 54.0% identified a clinically approved nanomedicine (Table 3). The majority of participants demonstrated good knowledge regarding nanomedicine, with 101 (73.7%) classified as having good knowledge, while 36 (26.3%) had poor knowledge based on the predefined cutoff point ($\geq 70\%$ considered good

knowledge). Overall, participants showed positive attitudes toward nanomedicine. About 61.3% believed it would improve treatment outcomes within the next 10 years, while 62.8% supported formal nanomedicine training for physicians. However, uncertainty about long-term safety was evident, with 37.2% reporting neutral responses. Approximately 63.5% would recommend nanomedicine if proven safe and effective, and 73.8% emphasised the importance of ethical considerations over rapid adoption.

Table 3. Knowledge about Nanomedicine among Medical Students

Question	Correct Response	Frequency	Percentage (%)
Definition of nanomedicine	Application of nanoscale materials (<100 nm)	93	67.9
Types of nanoparticles used in drug delivery	Liposomes, polymeric nanoparticles, dendrimers, metallic nanoparticles	100	73.0
Nanocarriers improve solubility & bioavailability	True	113	82.5
Nanoparticles are always non-toxic	False	96	70.1
EPR effect mechanism	Nanoscale size enabling accumulation in tumor tissue	89	65.0
Uncommon route of drug delivery	Telepathic	37	27.0
Challenge in nanomedicine	Scalability and reproducibility	56	40.9
Regulatory authority	National medicines regulatory authorities (e.g., FDA, EMA)	100	73.0
Example of nanomedicine	Doxil (liposomal doxorubicin)	74	54.0

Moderate neutrality regarding discussing nanomedicine and trust in regulatory authorities suggests a need for greater awareness and education (Table 4). Slightly more than half of the participants (70, 51.1%) demonstrated a negative attitude, while 67 (48.9%) had a positive attitude. Exposure to nanomedicine was limited: 38.7% never searched for related scientific information, while only 11.7% did so often or always.

Table 4. Participants' Attitudes Toward Nanomedicine

Statement	Strongly Disagree n (%)	Disagree n (%)	Neutral n (%)	Agree n (%)	Strongly Agree n (%)
Nanomedicine will significantly improve treatment outcomes in the next 10 years	14 (10.2)	16 (11.7)	23 (16.8)	48 (35.0)	36 (26.3)
Physicians should receive formal training on nanomedicine during medical school	14 (10.2)	11 (8.0)	26 (19.0)	42 (30.7)	44 (32.1)
Nanomedicine carries unknown long-term risks that worry me	14 (10.2)	21 (15.3)	51 (37.2)	29 (21.2)	22 (16.1)
I would recommend nanomedicine-based treatments if proven safe and effective	15 (10.9)	12 (8.8)	23 (16.8)	46 (33.6)	41 (29.9)
Ethical considerations are more important than rapid adoption	9 (6.6)	7 (5.1)	20 (14.6)	52 (38.0)	49 (35.8)
I feel comfortable discussing nanomedicine after reading overview articles	17 (12.4)	14 (10.2)	45 (32.8)	41 (29.9)	20 (14.6)
I trust regulatory authorities to ensure safety before approval	12 (8.8)	28 (20.4)	42 (30.7)	37 (27.0)	18 (13.1)

Only 16.8% had participated in nanomedicine-related research or laboratory activities, and 14.6% had recommended reading materials or advice to others. Additionally, just 21.9% often or always considered nano-formulations during pharmacology learning (Table 5). Overall practice toward nanomedicine was limited. About 38.7% of participants never searched for scientific information on nanomedicine, while only 11.7% did so often or always. Participation in nanomedicine-related research activities (16.8%) and recommending reading materials or advice (14.6%) were also low. Only 21.9% often or always considered nano-formulations during pharmacology learning. The majority of participants (112, 81.8%) demonstrated poor practice regarding nanomedicine, while only 25 (18.2%) had good practice based on the predefined scoring system. No significant associations were found between knowledge level and age ($\chi^2 = 2.576$, $p = 0.462$), gender ($\chi^2 = 1.701$, $p = 0.192$), academic year ($\chi^2 = 1.985$, $p = 0.851$), or faculty ($\chi^2 = 1.615$, $p = 0.656$). However, participants aged 24–26 years, females, and medical students showed slightly higher proportions of good knowledge (Table 6).

Table 5. Practice and Exposure Toward Nanomedicine

Item	Response	Frequency (n)	Percentage (%)
How often do you search for scientific information about nanomedicine?	Never	53	38.7
	Rarely	41	29.9
	Sometimes	27	19.7
	Often	6	4.4
	Always	10	7.3
Participated in research/lab work/presentation about nanomedicine	Yes	23	16.8
	No	114	83.2
Recommended reading or advised about nanomedicine	Yes	20	14.6
	No	117	85.4
Consider nano-formulations in clinical pharmacology learning	Never	28	20.4
	Rarely	38	27.7
	Sometimes	41	29.9
	Often	21	15.3
	Always	9	6.6

Table 6. Association between Sociodemographic Characteristics and Knowledge Level

Variable	Category	Poor knowledge n(%)	Good knowledge n(%)	χ^2	p-value
Age	18–20	2 (16.7%)	10 (83.3%)	2.576	0.462
	21–23	19 (31.1%)	42 (68.9%)		
	24–26	10 (20.4%)	39 (79.6%)		
	≥27	5 (33.3%)	10 (66.7%)		
Gender	Male	7 (38.9%)	11 (61.1%)	1.701	0.192
	Female	29 (24.4%)	90 (75.6%)		
Academic year	1st	2 (20.0%)	8 (80.0%)	1.985	0.851
	2nd	3 (25.0%)	9 (75.0%)		
	3rd	8 (34.8%)	15 (65.2%)		
	4th	10 (22.2%)	35 (77.8%)		
	5th	6 (33.3%)	12 (66.7%)		
	6th	7 (24.1%)	22 (75.9%)		
Faculty	Medicine	9 (20.0%)	36 (80.0%)	1.615	0.656
	Pharmacy	11 (27.5%)	29 (72.5%)		
	Dentistry	5 (27.8%)	13 (72.2%)		
	Medical Technology	11 (32.4%)	23 (67.6%)		

No statistically significant associations were found between students' attitudes and age ($\chi^2 = 1.840$, $p = 0.606$), gender ($\chi^2 = 2.011$, $p = 0.156$), academic year ($\chi^2 = 2.702$, $p = 0.746$), or faculty ($\chi^2 = 2.640$, $p = 0.450$). Although minor differences in positive attitudes were observed across groups, none reached statistical significance (Table 7). No significant associations were found between practice level and age ($\chi^2 = 4.863$, $p = 0.182$), gender ($\chi^2 = 0.035$, $p = 0.852$), academic year ($\chi^2 = 1.516$, $p = 0.911$), or faculty ($\chi^2 = 1.915$, $p = 0.590$), as shown in Table 8.

Table 7. Association between Attitude and Sociodemographic Variables

Variable	Category	Negative Attitude n (%)	Positive Attitude n (%)	χ^2	p-value
Age	18–20	6 (50.0%)	6 (50.0%)	1.840	0.606
	21–23	35 (57.4%)	26 (42.6%)		
	24–26	22 (44.9%)	27 (55.1%)		
	≥27	7 (46.7%)	8 (53.3%)		
Gender	Male	12 (66.7%)	6 (33.3%)	2.011	0.156
	Female	58 (48.7%)	61 (51.3%)		
Academic Year	1st	5 (50.0%)	5 (50.0%)	2.702	0.746
	2nd	6 (50.0%)	6 (50.0%)		
	3rd	11 (47.8%)	12 (52.2%)		
	4th	27 (60.0%)	18 (40.0%)		
	5th	7 (38.9%)	11 (61.1%)		
	6th	14 (48.3%)	15 (51.7%)		

Faculty	Medicine	21 (46.7%)	24 (53.3%)	2.640	0.450
	Pharmacy	18 (45.0%)	22 (55.0%)		
	Dentistry	10 (55.6%)	8 (44.4%)		
	Medical Technology	21 (61.8%)	13 (38.2%)		

Table 8. Association between Practice and Sociodemographic Variables

Variable	Category	Poor Practice n(%)	Good Practice n(%)	χ^2	p-value
Age	18–20	9 (75.0%)	3 (25.0%)	4.863	0.182
	21–23	49 (80.3%)	12 (19.7%)		
	24–26	44 (89.8%)	5 (10.2%)		
	≥27	10 (66.7%)	5 (33.3%)		
Gender	Male	15 (83.3%)	3 (16.7%)	0.035	0.852
	Female	97 (81.5%)	22 (18.5%)		
Academic Year	1st	9 (90.0%)	1 (10.0%)	1.516	0.911
	2nd	10 (83.3%)	2 (16.7%)		
	3rd	20 (87.0%)	3 (13.0%)		
	4th	35 (77.8%)	10 (22.2%)		
	5th	15 (83.3%)	3 (16.7%)		
	6th	23 (79.3%)	6 (20.7%)		
Faculty	Medicine	39 (86.7%)	6 (13.3%)	1.915	0.590
	Pharmacy	32 (80.0%)	8 (20.0%)		
	Dentistry	13 (72.2%)	5 (27.8%)		
	Medical Technology	28 (82.4%)	6 (17.6%)		

Discussion

The present study assessed knowledge, attitudes, and practices (KAP) regarding nanomedicine and its applications in drug delivery systems among medical students in Southern Libya. Overall, the findings indicate a relatively good level of theoretical knowledge (73.7%), but limited practical engagement (18.2%) and mixed attitudes toward nanomedicine. This pattern suggests that although students are increasingly aware of the potential applications of nanotechnology in medicine, opportunities for structured education and practical exposure remain limited. The majority of students had received little or no formal education in nanomedicine, with more than 93% reporting no previous lectures or courses on the subject. In addition, websites and social media were the most frequently reported information sources. Reliance on easily accessible digital resources may increase awareness of emerging technologies, but it may not provide the depth, scientific rigour, or critical understanding required for clinical applications. Previous literature has similarly emphasised the importance of integrating nanotechnology into health-science education and providing students with reliable, evidence-based educational resources [6-8].

Most participants demonstrated adequate understanding of basic nanomedicine concepts, including the role of nanoparticles in drug delivery and their potential to improve drug solubility and bioavailability. These findings are consistent with the expanding literature describing nanotechnology as an important approach for improving drug delivery, therapeutic efficacy, and pharmacokinetic properties [9]. However, knowledge was weaker regarding advanced issues, particularly barriers to clinical translation. Only 40.9% of participants correctly identified major challenges associated with clinical translation. Such gaps are important because successful translation of nanomedicine requires consideration of safety, toxicity, manufacturing consistency, regulatory requirements, and clinical evidence [10].

Despite relatively good knowledge, attitudes toward nanomedicine were not uniformly positive. Students recognised the potential of nanomedicine to improve future healthcare and supported the inclusion of nanomedicine in medical education, while concerns regarding long-term safety, toxicity, ethical issues, and clinical implementation were also evident. These concerns are consistent with the broader literature, which highlights the need to evaluate the potential biological effects and safety of nanoparticles alongside their therapeutic benefits [11]. Practical engagement was considerably lower than theoretical knowledge, with only 18.2% of students demonstrating good practice. Limited research participation, inadequate laboratory exposure, and the absence of nanomedicine-related activities within undergraduate education may contribute to this discrepancy. The gap between knowledge and practice highlights the importance of providing students with opportunities to participate in research, laboratory-based learning, and evidence-based discussions concerning nanomedicine.

No statistically significant associations were observed between KAP levels and age, gender, academic year, or faculty. This suggests that the educational gap may be broadly distributed among students rather than restricted to a particular demographic or academic subgroup. Therefore, educational interventions should be incorporated at the curriculum level rather than being targeted only at specific student groups. Overall, this study demonstrates that medical students in Southern Libya have a relatively good theoretical understanding of nanomedicine but limited practical exposure and incomplete knowledge of advanced translational issues. Incorporating fundamental nanomedicine concepts into

undergraduate medical curricula, providing reliable educational resources, and increasing opportunities for research and practical training may help prepare future healthcare professionals for the growing use of nanotechnology in medicine.

Conclusion

In conclusion, medical students in Southern Libya demonstrated generally good theoretical knowledge and moderate attitudes toward nanomedicine, but their practical exposure and engagement were limited. Integrating nanomedicine education, practical training, workshops, and research opportunities into undergraduate curricula may help bridge the gap between theoretical knowledge and practical application and better prepare students for future clinical and research roles.

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Data Availability Statement

The data supporting the findings of this study are available from the corresponding author upon reasonable request.

Authors Contribution

Omar Saad Saleh Abrika, Supervision, writing the original draft and editing; Heba Hamed Alarabi & Huda Mohammad Saleh, data collection, data curation.

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Ethical Issues

Ethical consideration: Ethical clearance was obtained from the Faculty of Pharmacy, Sebha University. Certificate No: 002\2025, approval date: 2nd/ November/ 2025.

Conflict of Interest

The authors declare that there is no conflict of interest.

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