


Knowledge and awareness of nursing students on the use of nanotechnology in healthcare

Conhecimento e conscientização de estudantes de enfermagem sobre o uso da nanotecnologia na área da saúde
 Conocimiento y concientización de estudiantes de enfermería sobre el uso de la nanotecnología en el área de salud

Burcu Totur Dikmen¹  <https://orcid.org/0000-0002-4221-6112>

Ezgi Bağrıaçık¹  <https://orcid.org/0000-0001-9061-1769>

Meryem Yavuz van Giersbergen²  <https://orcid.org/0000-0002-8661-0066>

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Corresponding author

Burcu Totur Dikmen
 E-mail: burcu.toturdikmen@neu.edu.tr

Associate Editor (Peer review process):

Edvane Birelo Lopes De Domenico
 (<https://orcid.org/0000-0001-7455-1727>)
 Escola Paulista de Enfermagem, Universidade Federal de São Paulo, São Paulo, SP, Brazil.

Abstract

Objective: To determine nursing students' awareness of nanotechnology usage in healthcare and to increase their sensitivity to the subject in the coming years.

Methods: This descriptive study was developed with 523 undergraduate nursing students. Data were collected using an online questionnaire between January and February 2018.

Results: The mean age of the students was 21.7 ± 3.9 years; 61.6% were female. According to 29.4% of students, nanotechnology should be used in medicine and for 38.0%, it should be especially used in the diagnosis-treatment of diseases and the production of new medical equipment. The highest percentage (38.8%) of students affirmed that time saving is the advantage of nanotechnology, while 39.1% mentioned its toxic effects as a disadvantage. Students also stated it should be used in the diagnosis and treatment of osteoporosis, cardiovascular diseases, diabetes mellitus, wound healing, and the production of new materials.

Conclusion: According to results of the study, students achieved the information about nanotechnology with their efforts. They thought nanotechnology should be used more in medicine, especially in the diagnosis-treatment of diseases and in the production of new medical equipment. They determined that time-saving and toxic effects are the top advantage and disadvantage of nanotechnology, respectively. We suggest the importance of including this technology in service training in hospitals and in curricula of faculties.

Resumo

Objetivo: Verificar o conhecimento dos estudantes de enfermagem sobre o uso da nanotecnologia na área da saúde e aumentar sua sensibilidade para o assunto nos próximos anos.

Métodos: Estudo descritivo realizado com 523 estudantes de graduação em enfermagem. Os dados foram coletados por meio de um questionário online entre janeiro e fevereiro de 2018.

Resultados: A média de idade dos alunos foi de $21,7 \pm 3,9$ anos; 61,6% eram do sexo feminino. 29,4% afirmaram que a nanotecnologia deve ser utilizada na medicina, e 38,0% afirmaram que ela deve ser utilizada especialmente no diagnóstico, tratamento de doenças e na produção de novos equipamentos médicos. O maior percentual (38,8%) afirmou que a vantagem da nanotecnologia é a economia de tempo, enquanto 39,1% apontaram como desvantagem os seus efeitos tóxicos. Os alunos também afirmaram que ela deve ser utilizada no diagnóstico e tratamento de osteoporose, doenças cardiovasculares, diabetes mellitus, cicatrização de feridas e na produção de novos materiais.

Conclusão: De acordo com os resultados do estudo, os alunos chegaram às informações sobre nanotecnologia com seus esforços. Para os alunos, a nanotecnologia deveria ser mais utilizada na medicina, especialmente

¹Faculty of Nursing, Department of Surgical Nursing, Near East University, Cyprus, Turkey.

²Faculty of Nursing, Department of Surgical Nursing, Ege University, Turkey.

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no diagnóstico-tratamento de doenças e na produção de novos equipamentos médicos. Eles determinaram a economia de tempo e os efeitos tóxicos como a principal vantagem e desvantagem da nanotecnologia, respectivamente. Sugerimos a importância de incluir esta tecnologia em treinamentos em hospitais e no currículo das faculdades.

Resumen

Objetivo: La nanotecnología cuenta con una amplia gama de usuarios en todo el mundo, especialmente en el área de la salud. La nanotecnología trae beneficios significativos para las prácticas de enfermería como resultado del aumento de su uso en la medicina. En este sentido, es necesario acelerar los estudios de enfermería y aumentar la concientización de los enfermeros. Este estudio fue realizado para verificar el conocimiento de los estudiantes de enfermería sobre el uso de la nanotecnología en el área de la salud y aumentar su sensibilidad para el asunto en los próximos años.

Métodos: Estudio descriptivo realizado con 523 estudiantes universitarios de enfermería. Los datos fueron recopilados por medio de un cuestionario realizado en línea entre enero y febrero de 2018.

Resultados: La edad promedio de los alumnos fue de $21,7 \pm 3,9$; el 61,6 % era del sexo femenino. El 29,4 % de los alumnos afirmó que la nanotecnología debe ser utilizada en la medicina, mientras que el 38,0 % afirmó que debe ser especialmente utilizada en el diagnóstico, en el tratamiento de enfermedades y en la producción de nuevos equipos médicos. El mayor porcentaje (38,8 %) afirmó que la ventaja de la nanotecnología es el ahorro de tiempo, mientras que el 39,1 % afirmó que sus efectos tóxicos son una desventaja. Los alumnos también afirmaron que se debe utilizar en el diagnóstico y tratamiento de la osteoporosis, enfermedades cardiovasculares, diabetes mellitus, cicatrización de heridas y en la producción de nuevos materiales.

Conclusión: De acuerdo con los resultados del estudio, los alumnos llegaron a la información sobre nanotecnología mediante sus esfuerzos. Los alumnos consideraban que la nanotecnología debería ser más utilizada en la medicina. Expresaron que se debe usar especialmente en el diagnóstico-tratamiento de enfermedades y en la producción de nuevos equipos médicos. Determinaron las principales ventajas y desventajas de la nanotecnología, como el ahorro de tiempo y los efectos tóxicos, respectivamente. Sugerimos que es importante incluir esta tecnología en capacitaciones en servicio en hospitales y en diseños curriculares de las facultades.

Introduction

A nanometer is a unit of measure that represents one-billionth of a meter. Through the Nanotechnology discipline, it is possible to perform physical, chemical, and biological events at the nanometer scale and to build materials with new properties by intervening in the structure of matter at the atomic and molecular levels.⁽¹⁻⁴⁾

Nanotechnology is used in many areas such as diagnosis, treatment, prevention of tissue injuries, production of patient tracking devices, pain control, drug development, and drug delivery systems, protection and improvement of health, water decontamination, information, communication technologies, and production of light and durable materials. The importance of nanotechnology, which finds solutions to many problems in healthcare, continues to increase in parallel with the increase in its usage areas.⁽⁵⁻⁸⁾

Nanotechnology has a wide range of users all over the world, especially in the field of healthcare, and it brings significant benefits to nursing practices as a result of the increase in its use in medicine.^(4,9,10) It is expected that bacteria and viruses will be detected faster and its control with appropriate treatment will be possible thanks to microchips developed in the field of microbiology. From patients' perspective,

unnecessary drug use can be prevented while from nursing's perspective, unnecessary drug administration and invasive interventions can be avoided until the results are clear.^(11,12)

When using drugs produced with nanotechnology in the treatment, nano-sized capsules are developed to provide the desired effect on the target organ and tissue. There is no unnecessary dosage and drug use-related side effects, so nurses do not have to struggle with the related problems.^(1,10,13,14) Likewise, the problems that can be brought by invasive procedures and use of opioid analgesic will be prevented by relieving pain with topical applications in pain management.^(4,10)

Nanotechnology is becoming a very effective method, especially in the prevention of infectious diseases. There is no space for the reproduction of microorganisms as a result of the use of silver powders in surface coatings. When the infection can be stopped, it significantly relieves the burden of nurses as it prevents nosocomial infections.^(7,15) With the use of nanotechnology in cancer treatment, the negative side effects of chemotherapy can be prevented, and the elimination of such side effects facilitates the daily life of patients and the management of their treatment by nurses.^(1,12)

As nanotechnology is a new technology, there is need for information in terms of healthcare and

nursing, as well as in other fields. The awareness of nanotechnology in nurses and other healthcare professionals should be increased, and studies on the knowledge level about nanotechnology are insufficient.⁽¹²⁾

This study was conducted to determine nursing students' awareness of nanotechnology usage in healthcare.

Methods

The nursing students from the Near East University, Faculty of Nursing, Northern Cyprus constituted the universe of this descriptive study. In total, 523 first, second, third, and fourth-year students who voluntarily accepted to participate in the study were included. Data were collected using an online questionnaire between January and June 2018.

A questionnaire prepared by the researchers^(4,12,16,17) was used in data collection. It consisted of two parts; the first part comprised questions on the characteristics of participants while the second part consisted of questions about their knowledge and opinions on nanotechnology. We also obtained the expert opinions from five faculty members, experts in the field, using the same questionnaire.

The statistical analysis of the data was conducted with the statistical package program SPSS 17.0 (SPSS Inc., Chicago, IL, USA). Mean, standard deviation, number, and percentage were calculated.

Approval by the ethics committee was obtained from the Research Ethics Committee of the University (YDU/2017/52-480); the required permission was also obtained from the dean of the nursing faculty. Students were informed about the study and gave their informed consent.

Results

The mean age of students was 21.7 ± 3.9 years; 61.6% were female; 40.0% graduated from regular high schools; 76.5% stated they were aware of nanotechnology; 45.0% knew the usage areas; 37.5% defined nanotechnology as biological methods and

systems in nature. Only 21.4% of participants stated they received information on nanotechnology; 69.6% of them obtained this information from the internet; 29.0% stated that nanotechnology is used in medicine; 44.1% said nanotechnology should be used in the treatment of diseases and healthcare; 39.1% stated that nanotechnology should be used in the production of new drugs (Table 1).

Table 1. General characteristics

General characteristics	n(%)
Mean age	21.7±3.9
Gender	
Female	322(61.6)
Male	201(38.4)
Alma mater (High school)	
Anatolian high school	207(39.6)
Regular high school	209(40.0)
Vocational high school	14(2.7)
Medical vocational high school	17(3.3)
Basic high school	10(1.9)
Other	66(12.5)

For 38.8% of students, nanotechnology prevents the loss of time; 39.1% stated it may have toxic effects; 93.7% considered that nurses should know about nanotechnology; 47.0% stated that nanotechnology is used in pain management; 80.7% of them thought it is used in medical imaging; 75.1% considered it is used in diagnosis; 60.0% stated it is used in the treatment of viral diseases (Table 2).

In this study, 73.0% of students thought it should be used in cancer diagnosis methods; 69.2% stated it should be used in the treatment of cancer; 60.4% stated it should be used in the prevention of genetic diseases. Students affirmed they did not have information about the use of nanotechnology in the treatment of diabetes (45.9%), heart (48.0%), and osteoporosis (45.7%) as chronic diseases. They stated that nanotechnology should be used in wound healing (54.3%), infection prevention (55.8%), disinfection methods (62.3%), and sterilization (57.9%). Students mostly stated that nanotechnology should be used in the production of new materials used in medicine. These materials were considered as artificial red blood cells (42.3%), operating room materials (68.8%), dressing materials (56.6%), and gloves (45.9%) (Table 3).

Table 2. The knowledge level about nanotechnology

Characteristics	n(%)
Awareness of nanotechnology	
Know	400(76.5)
Not know	123(23.5)
Knowledge level about nanotechnology	
Know its usage areas	180(45.0)
Know its harms	155(38.7)
Know its benefits	65(16.3)
Definition of nanotechnology according to students	
Biological methods in nature	196(37.5)
Small molecule technology	133(25.4)
Production technology based on molecular machine systems	45(8.6)
The way monomolecular components transform themselves into some useful form	29(5.5)
The way for transforming small components into more complex components	23(4.4)
Other	97(18.6)
The status of receiving information about nanotechnology	
Yes	112(21.4)
No	411(78.6)
Information source for nanotechnology (n=112)	
Internet	78(69.6)
Lessons	10(8.9)
Magazines	4(3.6)
Brochures	5(4.5)
Congress	6(5.4)
Other	9(8.0)
Usage fields of nanotechnology	
Medicine	154(29.4)
Physics	47(8.9)
Chemistry	24(4.6)
Biology	97(18.6)
Pharmacy	125(23.9)
Engineering	76(14.6)

Table 3. Students' opinions on the use of nanotechnology in healthcare

Characteristics	n(%)
Healthcare fields in which nanotechnology is used*	
Treatment	233(44.5)
Diagnosis	91(17.4)
Production of medical materials	117(22.4)
Other	77(14.7)
Not know	5(1.0)
Special healthcare fields in which nanotechnology is used	
Cancer	127(24.2)
Microbiology	145(27.7)
Novel drug production	205(39.1)
Wound healing	32(6.1)
Other	14(2.6)
Benefits of nanotechnology	
Increase in quality of life	76(14.5)
Low cost job	87(16.6)
Production in high quantity	138(26.3)
Prevention of time loss	203(38.8)
Other	19(3.6)
Harms of nanotechnological products	
Possible toxic effects	205(39.1)
DNA damage	126(24)
Inflammatory effect	45(8.6)
Possible harmfulness to beneficial bacteria	23(4.3)
Possible harmfulness to organs	67(12.8)
Other	57(10.8)
Nurses should have knowledge about nanotechnology	
Yes	490(93.7)
No	12(2.3)
Not know	21(4.0)
Nanotechnology is used in pain management	
Yes	246(47.0)
No	59(11.3)
Not know	217(41.7)

Continue...

Continuation.

Characteristics	n(%)
Nanotechnology is used in medical imaging.	
Yes	422(80.7)
No	19(3.6)
Not know	82(15.7)
Nanotechnology provides saving of time in diagnosis	
Yes	393(75.1)
No	39(7.5)
Not know	91(17.4)
Nanotechnology is used in the treatment of viral diseases	
Yes	314(60.0)
No	45(8.6)
Not know	164(31.4)
Nanotechnology is used in the diagnosis of cancer	
Yes	382(73.0)
No	39(7.5)
Not know	102(19.5)
Nanotechnology is used in the treatment of genetic diseases	
Yes	362(69.2)
No	128(16.3)
Not know	33(24.5)
Nanotechnology is used to prevent genetic diseases	
Yes	316(60.4)
No	60(11.5)
Not know	147(28.1)
It is used in the treatment of diabetes	
Yes	93(37.1)
No	190(17.0)
Not know	240(45.9)
It is used in the treatment of osteoporosis.	
Yes	222(42.4)
No	62(11.9)
Not know	239(45.7)
It is used in the treatment of cardiovascular diseases	
Yes	213(40.7)
No	59(11.3)
Not know	251(48.0)
It is used to stop bleeding	
Yes	210(40.2)
No	97(18.5)
Not know	216(41.3)
It is used in wound healing	
Yes	284(54.3)
No	69(13.2)
Not know	170(32.5)
It is used in infection prevention	
Yes	292(55.8)
No	66(12.7)
Not know	165(31.5)
It is used in sterilization	
Yes	326(62.3)
No	71(13.6)
Not know	126(24.1)
It is used in disinfection	
Yes	303(57.9)
No	68(13.0)
Not know	152(29.1)
It is used in artificial erythrocytes	
Yes	221(42.3)
No	50(9.5)
Not know	252(48.2)
It is used in surgical robots	
Yes	360(68.8)
No	51(9.8)
Not know	112(21.4)
It is used surgical textiles	
Yes	296(56.6)
No	78(14.9)
Not know	149(28.5)
It is used in surgical materials	
Yes	353(67.5)
No	47(9.0)
Not know	123(23.5)

Continue...

Continuation.

Characteristics	n(%)
It is used in medical gloves	
Yes	240(45.9)
No	94(18.0)
Not know	189(36.1)
It is used in medical dressing materials	
Yes	270(51.6)
No	74(14.2)
Not know	179(34.2)
It is used in urinary catheters	
Yes	254(48.6)
No	60(11.4)
Not know	209(40.0)
It is used in branules	
Yes	237(45.3)
No	66(12.6)
Not know	220(42.1)
It is used in orthopedic implants	
Yes	288(55.1)
No	57(10.9)
Not know	178(34.0)
It is used in dental implants	
Yes	297(56.8)
No	54(10.3)
Not know	172(32.9)
It is used in cardiovascular catheterization materials	
Yes	286(54.7)
No	41(7.8)
Not know	196(37.5)
It is used in plastic and reconstructive implants	
Yes	254(48.6)
No	56(10.7)
Not know	213(40.7)
It is used in medicines	
Yes	332(63.5)
No	54(10.3)
Not know	137(26.2)
It is used in insulin pumps	
Yes	231(44.2)
No	64(12.2)
Not know	228(43.6)
It is used in compression socks	
Yes	229(43.8)
No	66(12.6)
Not know	228(43.6)
It is used in mouthcare products	
Yes	227(43.4)
No	74(14.2)
Not know	222(42.4)

*More than one choice was selected

Discussion

This study was conducted to gain a better understanding on the knowledge of students' perceptions of the risks and benefits of nanotechnology applications. Nanotechnology has taken its place in the field of medicine, started to be developed and been used in a multidisciplinary approach. Nurses' benefit from nanotechnological developments to provide safe, effective, and quality care to their patients.^(10,12,16) In this study, the knowledge and opinions of nursing students about nanotechnology were evaluated and we found that only a small portion of students re-

ceived information about nanotechnology from the internet. Sayılan and Mercan (2016) conducted a study on the knowledge level of nursing students in terms of nanotechnology. They stated that only a small number of students had received information and their source was the internet.⁽¹²⁾ The concept of nanotechnology is not a term or concept that persons often encounter. As nanotechnology is a very new area, most people have only limited knowledge of this subject, except scientists in the field.⁽¹⁸⁻²⁴⁾ The literature supports this finding of the study. Nursing students had a lack of knowledge on the subject.

For 29.4% of students, nanotechnology should be used in medicine. Pektas et al. (2015) investigated the opinions of student teachers on nanotechnology; the participating teachers had information that nanotechnology should be used first in medicine, and then in the textile field.⁽²⁵⁾ In the studies of Sayılan and Mercan (2016), more than half of students stated that it should be used in medicine and healthcare.⁽¹²⁾ The change in the preference of nanotechnology usage areas in the studies may be related to the specializations of participants.

The opinions of students regarding its use in healthcare were examined; 38.0% of them thought it should be used in diagnosis, treatment, and medical devices. Harman and Şeker (2018) reported that science teacher candidates agreed on its use in healthcare areas such as diagnosis, drug production, and operating rooms.⁽²⁶⁾ The use of nanotechnology in the diagnosis and treatment of many chronic diseases is a totally novel approach. Now, it is more commonly thought to provide advantages in terms of treatment without damaging the target organ and surrounding tissues, fast diagnosis, and ease of use in pharmacology.^(4,22)

The students stated that nanotechnology should be used mostly in the production of new drugs, microbiology, and the diagnosis and treatment of cancer. Considering the literature, the most striking finding is the use of nanotechnology in healthcare. Nanotechnology is frequently used in medical imaging, pharmacology, microbiology, wound healing, tissue regeneration, treatment of some chronic diseases, vaccination, and genetics.^(7,10) The benefits of new drug production, mi-

crobiology, and its use in the treatment of cancer in particular are often mentioned.^(1,3,7,27) The fact that the students' sources of information about nanotechnology were the internet and activities such as conferences shows their comprehensive knowledge of the literature.

According to results of the study, students mentioned that nanotechnology has benefits such as saving time in applications and being able to produce more. In the literature, opportunities such as low cost of nanotechnology, increase in the quality of life, and more production possibilities are mentioned.⁽²⁸⁻³⁰⁾ Alpat et al. (2017) and Sahin & Ekli (2013) conducted studies to raise awareness of middle and high school students about nanotechnology; their findings support our results such as saving time and increasing the quality of life.^(31,32)

The risk perception of nanotechnology is limited but growing rapidly.⁽²²⁾ Students' opinions about the harms and benefits of nanotechnology were questioned, and they responded that nanotechnology may have toxic effects. Ateş and Üce (2017) investigated the awareness of nanotechnology in high school students, who mentioned that it provides a new competitive environment for countries in terms of its advantages but it may also harm other countries.⁽¹³⁾ It was also mentioned that it may cause negative results such as its use in war technology. In the results of the study of Alpat et al. (2017), students stated that it may have chemical danger and unwanted harmful effects when used in the war sector. When people have more awareness of nanotechnology, they have more information about its benefits or harms. It is argued that this technology should be included in formal education to teach it more comprehensively as a technology of the future.^(26,31)

In our study, students supported the use of nanotechnology in the diagnosis and treatment of diseases with significant prevalence such as, viral diseases, diabetes mellitus, cancer, cardiovascular diseases, pain management, and wound healing. It is expected that nanotechnology will have an important place in the treatment of osteoporosis, diabetes, wound healing, and infectious diseases, and

our study results are consistent with this expectation.^(16,33,34) The adoption of these innovations in nursing will increase the quality of care and provide more patient care potential.⁽¹²⁾

The fact that participants of the study were composed solely of nursing faculty students of the university, without including students of other health fields, is considered as a limitation. As results are limited to the university where this study was conducted, they cannot be generalized to all universities.

Conclusion

We determined that a small part of participating students received information and accessed the information on the internet with their efforts. Students thought nanotechnology should be used more in medicine. They expressed that it should be used especially in the diagnosis and treatment of diseases and in the production of new medical devices. Most of them argued that time-saving is the most important benefit of nanotechnology, while its toxic effects are its most important harm. Students also stated that it should be used in the diagnosis and treatment of many diseases (osteoporosis, cardiovascular diseases, diabetes mellitus, etc.), wound healing, and the production of new materials. Nanotechnology related topics should be included in nursing curricula, address societal impacts and promote an understanding of particular risks and benefits involved in each application of nanotechnology. In addition, further studies on the use of products produced by nanotechnology and their benefits in terms of satisfaction should be conducted.

Collaborations

All authors contributed with the conception and design or analysis and interpretation of data, writing of the article or relevant critical review of intellectual content and final approval of the version to be published.

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