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Knowledge and Attitude of Dental Students Regarding Nanotechnology in Dentistry

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ABSTRACT ***Objectives:*** *The aim of this study was to evaluate the knowledge, attitude, and practice of nanotechnology in dentistry among dental students at King Saud University (KSU) and Princess Nourah University (PNU) in Riyadh, Saudi Arabia.*
Materials and Methods: This cross-sectional study was conducted with 3rd, 4th, and 5th year undergraduate dental students at KSU and PNU, and the students were invited to voluntarily complete a self-administered questionnaire. The questionnaire assessed demographic data and knowledge regarding general nanotechnology and nanotechnology use in dentistry. Data were coded, entered into a Microsoft Excel spreadsheet, and analyzed using statistical software.
Results: A total 251 dental students participated in this survey, and 70% of the participants were female. Of the participants, 30.3% had never heard of nanotechnology, and 88.4% of the students recommended having a lecture about nanotechnology in their academic curriculum. Of the participants, 62.5% thought that the use of nanotechnology in dentistry will be supplemental rather than fundamental.
Conclusion: This study showed that there is a lack of awareness of nanotechnology applications in dentistry among dental students at KSU and PNU. This study indicates that nanotechnology should be incorporated into the dentistry curriculum to increase the knowledge, attitude, and practice of nanotechnology in dentistry.
Keywords: *Nanotechnology, Nanodentistry, Dentistry, KSA*

I. INTRODUCTION

In 1959, at the annual meeting of the American Physical Society, physicist and Nobel laureate Richard P. Feynman presented the first lecture on atomic scale technology and engineering entitled "There is plenty of room at the bottom".[6][14] In this famous speech, Feynman stated that the manipulation of atoms and molecules would contribute to the development of many new inventions, and he concluded his lecture stating "this is a development which I think cannot be avoided", thus this speech marks the beginning of nanoscience and nanotechnology and Feynman is considered the father of modern nanotechnology. The field of nanotechnology began in 1958 and various developments in nanotechnology are summarized in Table 1.

Science is currently in the nanotechnology epoch, and a variety of nanotechnologies are being used in industrial, defense, consumer, and biomedical applications. The term "nano" is a prefix that originated from a Greek word meaning "dwarf", one nanometer (nm) equals 10-9 m, and atoms are ~0.1 nm. In the medical field, nanotechnology is used in the development of drug delivery systems that specifically target cancer cells in the body without damaging healthy cells.

R.A. Freitas Jr. first used the term nanodentistry in 2000 when discussing the future of nanodentistry, tissue engineering, and dental nanorobots. Currently, nanorobots can be used in orthodontics to move, rotate, and straighten teeth without pain within minutes or hours. Because of the drawbacks of amalgam and composite materials, the quality of dental materials has been a concern for more than a decade, and nanotechnology has led to the development of better and more durable implant and composite materials for improved dental care. Because nanoparticles are < 100 nm, the surface area per gram of powder is very high, thus the incorporation of nanoparticles into composite materials will likely change the properties of the materials, including increasing the aesthetic and wearable properties.[6]

The goal of nanotechnology is to prevent rather than to treat oral diseases, particularly dental caries and periodontal diseases. Nanoparticles, such as calcium carbonate, have good retention on oral surfaces and slow continuous release of high concentrations of calcium ions into the surrounding oral fluids. Calcium carbonate nanoparticles can also increase the pH of the surrounding fluid, thereby remineralizing incipient lesions. In addition, nanoparticles of calcium fluoride have been shown to be highly soluble and reactive, thereby increasing the fluoride concentration in oral fluids and enhancing tooth remineralization.[10] Hydroxyapatite,

Ca10 (PO4)6 (OH)2 , is a a non-active calcium phosphate and structural component in enamel, dentin, and bone.[11]

Although nanotechnology has been introduced in dentistry at various dental academic levels, the aim of this research survey was to evaluate knowledge of and attitude towards nanotechnology in dentistry among undergraduate dental students at King Saud University (KSU) and Princess Nourah University (PNU).

II. METHODOLOGY

This was a cross-sectional study in which paper and online questionnaires were distributed to 3rd, 4th, and 5th level undergraduate dental students at KSU and PNU in Saudi Arabia. Participation was voluntary and the study included a random sample of 251 participants. Inclusion criteria included any 3rd, 4th, or 5th level dental students at KSU and PNU. There were no exclusion criteria.

The questions were simple and concise multiple-choice questions that addressed knowledge and attitude toward nanotechnology in dentistry. The questions were subdivided into five categories: 1) demographic data, 2) attitude toward nanotechnology, 3) assessment of general nanotechnology knowledge, 4) assessment of knowledge regarding the application of nanotechnology in dentistry, and 5) assessment of knowledge regarding the future of nanotechnology.

The study variables were demographic data, including age, gender, level, university, and knowledge regarding nanotechnology and the application of nanotechnology in dentistry.

Participation in the study was voluntary. The first page of the online and paper questionnaires explained the purpose of the research and assured the confidentiality of the collected data. Ethical approval was obtained from the Institutional Review Board (IRB) and the College of Dentistry Research Center (CDRC) at King Saud University, Riyadh, Saudi Arabia.

Data were coded and entered into a Microsoft Excel spreadsheet and analyzed using the

Statistical Package for Social Sciences (SPSS) software. Descriptive statistics, including frequencies and percentages, were analyzed by one-way ANOVA, p-values < 0.05 were considered statistically significant.

III. RESULTS

A total of 251 of undergraduate dental students responded to the survey. Most of the participants were between 22–24 years of age (67%) and the majority were female (70%). Ninety-one (36%) of the participants were 3rd year students, 81 (32%) were 4th year students, and 79 (31%) were 5th year students (Table 2).

Regarding knowledge of nanotechnology, 30.3% of students never heard of nanotechnology, whereas 26.7% of students had heard of nanotechnology from an instructor in class. One hundred sixteen (46.2%) of students responded that nanotechnology referred to < 100 nm, 95 (37.8%) of students responded that nanotechnology referred to < 100 µm, and 31 (12.4%) responded that nanotechnology referred to < 100 µL. Out of 251 participants, 218 (86.9%) thought that nanotechnology is expensive but beneficial, and only 26 (10.4%) thought that nanotechnology is expensive and hazardous (Table 3). Two hundred and sixteen (86.1%) students thought that success action of nanoparticles involves better penetration of materials with nanoparticles than with larger particles, whereas 27 (10.8%) respondents thought that success action of nanoparticles involves easier dissolution in chemical agents.

Regarding knowledge of the application of nanotechnology in dentistry, most of the undergraduate dental students (84.9%) thought that the use of nanotitanium implants increases the quality and success rates of implants, whereas 12.7% of students thought that the use of nanotitanium implants does not affect the quality and success rates of implants. Eighty-seven (34%) of the participants thought that the application of nanotechnology in dentistry will be fundamental, 157 (62.5%) of the participants thought that the application of nanotechnology in dentistry will be supplemental, and 7 (2.8%) of the participants thought that nanotechnology will be useless in dentistry. Of the participants, 63.3% believed that there is a lack of clinical trials on nanotechnology-based approaches, whereas 32.3% believed that nanotechnology is affordable (Table 4).

Regarding the future of nanotechnology, 61% of dental students believed that nanotechnology can benefit human and environmental life, whereas 33.9% believed that nanotechnology can have both beneficial and harmful effects due to extensive exposure to the nanoparticles. The majority (91.6%) of students believed that nanotechnology in dentistry will improve treatment quality in the future, whereas only 7.2% of students believed that nanotechnology will not affect treatment quality. Lastly, 222 (88.4%) of respondents recommended having nanotechnology lectures in the academic curriculum (Table 5).

IV. DISCUSSION

Nanotechnology has attracted many researchers and has been shown to be beneficial. This survey evaluated the knowledge and attitude of nanotechnology in dentistry among undergraduate dental students at KSU and PNU. The survey was distributed to 3rd, 4th, and 5th level students, and 251 students participated. Of the participants, 69.7% had heard of nanotechnology, whereas 30.3% had never heard of nanotechnology, and

these results are similar to the results in a study by Sakr et al. in which 69.3% of participants had heard of nanotechnology.[12] But, Ali et al. study showed that only 50.8% of their students knew about nanotechnology.[13] In our study, most of the students who had not heard of nanotechnology were 3rd and 4th year students. However, most of the students (88.4%) recommended inclusion of a nanotechnology lecture in the academic curriculum indicating that students are willing to learn about the benefits of new technologies, such as nanodentistry.

Nanotechnology has been incorporated as a university major in developed countries, including the UK and the USA.[14] Based on questions regarding general nanotechnology knowledge, 46.2% of students thought that nanoparticles are < 100 nm. In fact, particles with dimensions from 1–100 nm allow for complete control of matter.[15] Most of the students (86.9%) believed that nanotechnology is beneficial yet expensive. Although nanotechnology is currently considered to be expensive, it is expected to be cost effective and more efficient in the future.[16]

Regarding knowledge of the application of nanotechnology in dentistry, 84.4% of students thought that the use of nanotitanium implants can increase the quality and success rates of implants, however Ali et al. showed that 95% of students never used nanoimplants in their clinicals.[13] It has been shown that the use of nanotechnology in implants accelerates and increases bone-implant integration.[17] Of the dental students, 62.5% thought that the application of nanotechnology in dentistry will be supplemental. Currently, nanotechnology plays a supplemental role in dentistry, but in the future, nanotechnology could change health care in fundamental ways.[18]

Regarding the future of nanotechnology in dentistry, 33.9% thought that nanotechnology can affect human and environmental life in both beneficial and harmful ways due to extensive exposure to nanoparticles. Concerns regarding the health and environmental risks caused by extensive exposure to nanoparticles led to the emergence of the nanotoxicology and nanomedicine disciplines.[4] Nanotoxicology is the study of potential adverse health effects caused by nanoparticles, and this field has developed due to the limited, reliable toxicity data for nanoparticles. [6] In addition, 91.6% of students thought that nanotechnology will improve the quality of treatment in dentistry. Currently, nanotechnology affects human life daily and has become the foundation for important industrial applications and is expected to change health care in fundamental ways.[19] [22] Our survey showed that both our male and female dental students had little knowledge of nanotechnology. Additionally, there was no difference in the knowledge of the application of nanotechnology in dentisty amond our 3rd, 4th, and 5th year students.

V. CONCLUSION

The main limitations of this study were that the participants were limited to two schools in Riyadh and that the majority of the participants were female because PNU is a public women's university. This study showed a lack of awareness of nanotechnology use in dentistry among dental students at KSU and PNU. This study indicates that nanotechnology should be incorporated into the dentistry curriculum to increase the knowledge, attitude, and practice of nanotechnology in dentistry.

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Table 1. The development of nanotechnology [2]

Date	Author	Discription of work
1959	R. Feynman	Initiated thought process
1974	Taniguchi	The term nanotechnology was used for the first time.
1981	IBM Scanning Tunneling Microscope	
1985	"Bucky Ball"	
1986	K. Eric Drexler	First book on nanotechnology Engines of Creation published, Atomic Force Microscope
1989	IBM logo was made with individual atoms	
1991	S. Iijima	Discovered Carbon Nano tube for the first time.
1999	R. Freitas	1st nano medicine book "Nano medicine" was published
2000	For the first time National Nanotechnology Initiative was launched	
2001	Feynman Prize	For developing theory of nanometer-scale electronic devices and for synthesis and characterization of carbon nanotubes and nano wires, Feynman Prize in Nanotechnology was awarded
2002	Feynman Prize	Feynman Prize in Nanotechnology was awarded for using DNA to enable the self-assembly of new structures and for advancing our ability to model molecular machine systems.
2003	Feynman Prize	Feynman Prize in Nanotechnology was awarded for modeling the molecular and electronic structures of new materials and for integrating single molecule biological motors with nano-scale silicon devices.
2004	Feynman Prize	First policy conference on advanced nanotech was held. First center for nano mechanical systems was established; Feynman Prize in Nanotechnology was warded for designing stable protein structures and for constructing a novel enzyme with an altered function.
2005-2010	3D Nano systems like robotics, 3D networking and active nano products that change their state during use were prepared.	
2011	Era of molecular nano technology started	

Table 2. The demographic characteristics of the participants (n=251).

Variables	Frequency	Percentage
Gender:		
Male	78	31.1%
Female	173	68.9%
In which year you are?		
3rd year	91	36.3%
4th year	81	32.3%
5th year	79	31.5%
In which age group you are?		
19-21	77	30.7%
22-24	168	66.9%
25-26	6	2.4%
In which university you are?		
KSU	161	64.1%
PNU	90	35.9%

Table 3. Results of the knowledge of nanotechnology survey		
Variables	**Frequency**	**Percentage**
From where did you hear about Nanotechnology?		
Attended conferences and media about Nanotechnology	25	10%
Read articles about nanotechnology	34	13.5%
Had an instructor who talked about nanotechnology in class	67	26.7%
From lectures	49	19.5%
Never heard of it	76	30.3%
When you hear the term nanotechnology, what length-scale "typically" comes to your mind?		
Less than 100 nm	116	46.2%
Less than 100 mm	9	3.6%
Less than 100 µm	95	37.8%
Less than 100 µL	31	12.4%
Do you think nanotechnology cost is :		
Expensive and hazardous	26	10.4%
Cheap and beneficial	7	2.8%
Expensive and beneficial	218	86.9%

Table 4. Results of the knowledge of the application of nanotechnology in the specialty of dentistry survey.		
Variables	**Frequency**	**Percentage**
Do you think using the Nano-titanium implant can:		
Can increase the quality and success rate of the implant	213	84.9%
Decrease the quality and success rate of the implant	6	2.4%
Will not affect the implant	32	12.7%
Do you the think the application of nanotechnology in dentistry will be:		
Fundamental	87	34.7%
Supplemental	157	62.5%
Useless	7	2.8%
The Nanotechnology based on the diagnostic approach have:		
Significant lack of clinical trials	159	63.3%
Affordable cheap materials	11	4.4%
Affordable experienced researchers	81	32.3%