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Research Article

What do Nigerian Dentists Know About Nanodentistry?

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Abstract

Background: The potentials of nanotechnology in the field of dentistry are enormous. This study evaluated the level of awareness and knowledge of a population of Nigerian dentists about nanodentistry.

Method: This was a descriptive cross-sectional study of a population of Nigerian dentists. The study assessed the level of awareness regarding 6 different areas of dentistry where nanotechnology has been utilized and also assessed the knowledge of nanodentistry among the respondents.

Results: Awareness of the use of nanotechnology in development of dental materials was highest among the respondents. Only 8.8% of the respondents were extremely aware that bottom-up approach and top-down approach are approaches to nanodentistry while those that were not at all aware about bottom-up approach and top-down approach as approaches to nanodentistry accounted for 39.7% respectively. A higher proportion (41.5%) of the respondents reported excellent level of knowledge (CI 27-9-41-5) while 38.2% had a good level of awareness regarding areas of dentistry where nanotechnology has been utilized (CI 27.9-48.9).

Conclusion: The overall level of knowledge and awareness of nanodentistry among the study population was fair with the knowledge of its application in dental material science high. Continuous education on the applications of nanoparticles in all aspects of dentistry will go a long way to improve the knowledge and awareness of nanodentistry.

Keywords: Nanodentistry; Dentists; Knowledge; Application

Introduction

Nanotechnology is a branch of technology that works on dimensions less than 100nm hence, very much concerned with structures at the molecular and atomic scale [1]. It has been extensively employed in dentistry. There are two general approaches for the synthesis of nanomaterials which is applicable to nanodentistry; the Bottom-up which assembles small components into compound structures [2-5] and Top-down which involves the creation of small structures by using bigger ones to guide their assembly [3,4,6]. The bottom-up has the potential of creating less waste and products with fewer surface defects unlike those of the Top-down approach.

Nanotechnology using the top-down approach has been employed in the manufacture of dental nanomaterials such as nanocomposites. It is thought to improve dental composites aesthetics by making the material more translucent as well as improve its wear properties [1]. The top-down approach has also been em-

ployed in the manufacture of nanoadhesives, nano light-curing glass ionomer restoration, impression materials, nano-composite denture teeth, nanoencapsulation, dentrifices, laser plasma application for periodontitis, materials for induction of osseous growth, prosthetic implants, radiopacity, orthodontic wires, nano needles, nano sterilizing solution and bone replacement materials [3].

Dental nanorobotics is the application of nanotechnology via the bottom-up approach in various aspects of dentistry. They have been employed in local nanoanaesthesia [7], hypersensitivity cure [8], tooth repositioning [3], therapeutic aid in oral diseases [9], gene therapy [7], diagnosis of oral cancer [10], dental durability and cosmetics [9] and continuous oral health maintenance using mechanical dentifrobots [11].

The goal of modern dentistry is prevention rather than cure. Nanotechnology offers new approaches for preventive therapies in oral diseases such as dental caries (antibacterial nanotherapy, biomimetic remineralisation-reversing an incipient caries and preventing recurrent decay, caries vaccine) and periodontal diseases [1].

Unlike in medicine, dentistry has not yet seen considerable transition from research laboratory practices to clinical chairs in terms of diagnostic dentistry [1]. Notwithstanding, contributions from nanotechnology have been in the form of atomic force microscopy, nanodiagnostics in form of photosensitizers and carriers [7], imaging contrast enhancers and biochips [1].

The potentials of nanotechnology in the field of dentistry are enormous. However, issues of public acceptance, ethics, regulation, and human safety [3] have the propensity to undermine its benefit to the dental profession. It is therefore important to interrogate the level of awareness and knowledge of a population of Nigerian dentists about nanodentistry.

Methodology

This was a descriptive cross-sectional study of Dentists practicing at the University of Benin Teaching Hospital. Data was garnered by means of a self-administered questionnaire which consisted of sections. The first section sought information on the socio-demographic characteristics (gender, age, status and specialty) of the respondents. The second section assessed the level of awareness regarding 6 different areas of dentistry where nanotechnology has been utilized. The responses for this section where Lickert's scale responses which were scored as follows: Not at all aware =0; slightly aware= 1; somewhat aware=2; moderately aware=3; extremely aware =4. The highest possible score was 24 and the lowest 0. The total awareness score was graded as < 25% - poor,25%-50% - moderate, 51%-75% - good, and> 75% - excellent level of awareness.

The third section consisted of 41 questions which assessed the knowledge of nanodentistry among the respondents. The scores obtained were interpreted into four segments as done in previous studies [12,13]: < 25% - weak,25%-50% - moderate,51%-75% - good, and> 75% - excellent level of knowledge.

Data collated was analysed using IBM SPSS version 21.0. Descriptive statistics in the form of counts, frequency and percentages was employed in the statistical analysis. Measure of association was checked using Chi square test. Statistical significance was set at ≥0.05.

Results

A total of 68 responses were received out of the 80 questionnaires distributed giving a response rate of 85%. The respondents consisted of more males (58.8%) compared to females (41.2%). A higher proportion of the respondents were aged between 31-35 years (39.7%) and 50.0% were junior residents. A large proportion (48.5%) of the respondents did not have any specialty/did not state their specialty while maxillofacial Surgery/Pathology/Medicine made up 20.6% (Table 1).

Awareness regarding various areas of dentistry where nanotechnology has been utilized is shown in table 2. Awareness of the use of nanotechnology in development of dental materials was highest among the respondents; with 33.8% and 14.7% of the respondents being moderately and extremely aware respectively. The use of nanotechnology in dental implants revealed that 30.9% and 8.8% of the respondents were moderately and extremely aware respectively. About a third (33.8%) of the respondents were moderately aware of preventive nanodentistry as an area of nanotechnology application, while 13.2 were extremely aware. Only 8.8% of the respondents were extremely aware that bottom-up approach and top-down approach are approaches to nanodentistry while those that were not at all aware about bottom-up approach and top-down approach as approaches to nanodentistry accounted for 39.7% respectively.

Characteristics	Frequency	Percent
Age group (years)		
≤ 30	19	27.9
31-35	27	39.7
>35	22	32.4
Gender		
Male	40	58.8
Female	28	41.2
Status		
House officer	18	26.5
Junior Resident	34	50.0
Senior Resident	7	10.3
Consultant	9	13.2
Specialty		
Not stated	33	48.5
Restorative	6	8.8
Maxillofacial Surgery/Pathology/ Medicine	14	20.6
Periodontics/Community Dentistry/Family medicine	8	11.8
Orthodontics/Paedodontics	7	10.3

Table 1: Socio-demographic distribution of the respondents.

The knowledge of nanodentistry and awareness of areas of application of nanotechnology in dentistry among the respondents is shown in table 3. A higher proportion (41.5%) of the respondents reported excellent level of knowledge (CI 27-9-41-5) while 38.2% had a good level of awareness regarding areas of dentistry where nanotechnology has been utilized (CI 27.9-48.9).

Majority (80.9%) knew that nano particles in composite was part of development of dental materials in nanodentistry while 52.9% and 63.2% of respondents respectively knew that sub-micron grain size ceramics for the production of all ceramic restoration; and the extension of the longevity of resin-dentin bond were as a result of the application of nanotechnology in dental materials.

About two thirds (66.2%) of the respondents stated that nano particles in composite improves the aesthetic of the materials by making it more translucent while 63.2% were of the opinion that nano particles in composite improves or modifies the wear properties. Nanometersized powders for the production of ceramic monolith was reported to improve aesthetic (63.2%), improve wear properties (54.4%) and maximize strength of the ceramic (51.5%).

Forty (58.8%) respondents claimed that the extension of longevity of resin - dentin bond occurred via the protection of expound collagen through reinforcement, cross-linking and biomimetric remineratlization, others attributed the longevity of resin

	Not at all aware	Slightly aware	Somewhat aware	Moderately aware	Extremely aware
Development of dental materials	11 (16.2)	10 (14.7)	14 (20.6)	23 (33.8)	10 (14.7)
Dental implants	14 (20.6)	9 (13.2)	18 (26.5)	21 (30.9)	6 (8.8)
Preventive nanodentistry	12 (17.6)	11 (16.2)	13 (19.1)	23 (33.8)	9 (13.2)
Diagnostic nanodentistry	17 (25.0)	8 (11.8)	17 (25.0)	18 (26.5)	8 (11.8)
Approaches to nanodentistry					
Bottom - up approach	27 (39.7)	8 (11.8)	14 (20.6)	13 (19.1)	6 (8.8)
Top - down approach	27 (39.7)	9 (13.2)	13 (19.1)	13 (19.1)	6 (8.8)

Table 2: Awareness regarding areas of dentistry where nanotechnology has been utilized among the respondents.

Level of Knowledge	Frequency	Percent	Confidence interval
Weak	17	25.0	18.8-33.0
Moderate	11	16.2	8.5-22.4
Good	17	25.0	18.5-32.7
Excellent	23	33.8	27.9-41.5
Level of Awareness			
Poor	6	8.8	5.2-15.0
Moderate	20	29.4	21.7-36.8
Good	26	38.2	27.9-48.9
Excellent	16	23.5	17.6-32.4

Table 3: Knowledge and awareness of Nanodentistry among the respondents.

- dentin bond to the inhibiting of the actions of MMPs (30.9%) and modification of the adhesive resin monomer (54.4%).

Nanofillers and nano gels listed by the respondents included Zirconica (57.4%), Hydroxyl Apatite (38.2%), Colloidal Silica (47.1%), Barium aluminosilicate nanofiller (57.4%), Reactive nanogels (41.2%) and Bioactive calcium/sodium phosphosilicate (45.6%).

Surface topography of dental implants that have been employed to induce controlled nano surface features as stated by the respondents were; Lithography (29.4%), Anodization (35.3%), ionic implantation (29.4%), Radio - frequency plasma treatments (33.8%) and Nanocrystaline diamond coat (39.7%).

Respondents identified the following preventive nanodentistry applications; antibacterial nanotherapy (58.8%), biomimetric remineralization-reversing incipient caries (50.0%), biomimetric remineralization - recurrent decay (39.7%), nanorobots mouthwash (47.1%), caries vaccine (39.7%), nanorobots tooth paste (51.5%) and nano structured doxycycline (47.1%). Prevention of bone loss by local application of nanostructured doxycycline gel and prevention of calculus accumulation by use of dentrifrobots accounted for 64.7% and 59.8% of the responses respectively.

Diagnostic nanodentistry was reported in the form of atomic force microscopy and oral biofilms characterization of bacteria and measurement of their adhesion to different substrates by 39.7% of the respondents; Imaging contrast enhancers for diagnosis of oral cancer (51.5%) and biochips and salivary biomarkers (54.4%).

Bio - nano interfaces of clinical significance were reported by the respondents as adhesive resin - dentin interface (60.3%) and dental implant - bone interface (55.9%). Therapeutic nanodentistry applications noted by respondents include; dentin hypersensitivity (73.5%), root canal disinfection (66.2%), oral cancer (38.2%), tissue engineering (66.2%) and drug delivery (69.1%).

There was no statistically significant association between age, gender, status and specialty of the respondents with level of awareness regarding areas of dentistry where nanotechnology has been utilized (Table 4).

There was no statistically significant association between gender, status and specialty of the respondents with level of knowledge of nanodentistry. However, there was statistically significant association between the age of the respondents and level of knowledge of nanodentistry (P = 0.03) with a higher proportion (33.3%) of those aged between 31-35 having excellent level of knowledge and a higher proportion (47.4%) of those aged ≤30 years having weak knowledge of nanodentistry (Table 5).

Discussion

Nanotechnology has necessitated a paradigm shift in all aspects of health care from traditional to state-of-the-art patient care and dentistry is no exception [3]. Nano-enabled technologies are thought to provide an alternative and superior approach to assessing the onset or progression of diseases, identify targets for treatment interventions as well as facilitate the design of more biocompatible, microbe resistant dental materials and implants [14]. This study revealed a low awareness of the two approaches to nanodentistry. This may be attributed to failure on the part of the respondents to take advantage of continuous dental education to update their professional knowledge.

In dentistry, various aspects of dental diagnostics, therapeutics and cosmetic dentistry [15,16] have been revolutionised by nanodentistry. The findings of this study show that overall, the respondents have a limited knowledge about the application of nanodentistry, a finding similar to previous report [17].

The respondents were knowledgeable about the specific use of nanotechnology in the development of dental materials while their awareness was low on the application of nanotechnology in preventive nanodentistry. and the approaches to nanodentistry. This may be attributed to the fact that currently, nanotechnology has

Characteristics	Level of awareness				Total
	Poor	Moderate	Good	Excellent	
Gender					P = 0.96
Male	3 (7.5)	12 (30.0)	16 (40.0)	9 (22.5)	40 (100.0)
Female	3 (10.7)	8 (28.6)	10 (35.7)	7 (25.0)	28 (100.0)
Age group					P = 0.24*
≤ 30	3 (15.8)	8 (42.1)	6 (31.6)	2 (10.5)	19 (100.0)
31-35	2 (7.4)	6 (22.2)	9 (33.3)	10 (37.0)	27 (100.0)
>35	1 (4.5)	6 (27.3)	11 (50.0)	4 (18.2)	22 (100.0)
Status					P = 0.38*
House Officer	2 (11.1)	9 (50.0)	6 (33.3)	1 (5.6)	18 (100.0)
Junior Resident	3 (8.8)	9 (26.5)	12 (35.3)	10 (29.4)	34 (100.0)
Senior Resident	1 (14.3)	1 (14.3)	3 (42.9)	2 (28.6)	7 (100.0)
Consultant	0 (0.0)	1 (11.1)	5 (55.6)	3 (33.3)	9 (100.0)
Specialty					P = 0.13
Not stated	4 (12.1)	14 (42.4)	12 (36.4)	3 (9.1)	33 (100.0)
Restorative	0 (0.0)	1 (16.7)	1 (16.7)	4 (66.7)	6 (100.0)
Maxillofacial Surgery/ Pathology/ Medicine	0 (0.0)	3 (21.4)	7 (50.0)	4 (28.6)	14 (100.0)
Periodontics/ Community Dentistry/ Family medicine	1 (12.5)	2 (25.0)	3 (37.5)	2 (25.0)	8 (100.0)
Orthodontics/ Paedodontics	1 (14.3)	0 (0.0)	3 (42.9)	3 (42.9)	7 (100.0)
Total	6 (8.8)	20 (29.4)	26 (38.2)	16 (23.5)	68 (100.0)

Table 4: Relationship between level of awareness regarding areas of dentistry where nanotechnology has been utilized and demographic characteristics of the respondents.
*Fischer's Exact.

Characteristics	Level of Knowledge				Total
	Weak	Moderate	Good	Excellent	
Gender					P = 0.40
Male	9 (22.5)	6 (15.0)	13 (32.5)	12 (30.0)	40 (100.0)
Female	8 (28.6)	5 (17.9)	4 (14.3)	11 (39.3)	28 (100.0)
Age group					P = 0.03*
≤ 30	9 (47.4)	2 (10.5)	6 (31.6)	2 (10.5)	19 (100.0)
31-35	6 (22.2)	6 (22.2)	6 (22.2)	9 (33.3)	27 (100.0)
>35	2 (9.1)	3 (13.6)	5 (22.7)	12 (54.5)	22 (100.0)
Status					P = 0.36*
House Officer	7 (38.9)	4 (22.2)	5 (27.8)	2 (11.1)	18 (100.0)
Junior Resident	7 (20.6)	4 (11.8)	10 (29.4)	13 (38.2)	34 (100.0)
Senior Resident	1 (14.3)	1 (14.3)	2 (28.6)	3 (42.9)	7 (100.0)
Consultant	2 (22.2)	2 (2.2)	0 (0.0)	5 (55.6)	9 (100.0)
Specialty					P = 0.66
Not stated	8 (24.2)	6 (18.2)	8 (24.2)	11 (33.3)	33 (100.0)
Restorative	1 (16.7)	0 (0.0)	2 (33.3)	3 (50.00	6 (100.0)
Maxillofacial Surgery/ Pathology/ Medicine	5 (35.7)	3 (21.4)	3 (21.4)	3 (21.4)	14 (100.0)
Periodontics/ Community Dentistry/ Family medicine	2 (25.0)	0 (0.0)	1 (12.5))	5 (62.5)	8 (100.0)
Orthodontics/Paedodontics	1 (14.3)	2 (28.6)	3 (42.9)	1 (14.3)	7 (100.0)
Total	17 (25.0)	11 (16.2)	17 (25.0)	23 (33.8)	68 (100.0)

Table 5: Relationship between level of knowledge of nanodentistry and demographic characteristics of the respondents.
*Fischer's Exact.

had its greatest impact on restorative dentistry by offering refinements to already clinically proven resin based composite systems using the top bottom approach [3]. Nanotechnology is undoubtedly likely to improve dental preventions and treatments but it is still in development phase and its use in clinical settings is limited by concern of safety and cost-effectiveness [18]; this may be the reason for the observations noted in this study. Similarly, awareness about the application of nanotechnology in dental implants among the respondents in this study was high compared to a previous study that reported a low awareness [19]. Furthermore, the use of nanotechnology in various fields is an evolving process which is sure to enhance the various prevailing dental procedures with the possibility of more materials and procedures based on nanotechnology in the future [20].

Nano particles in composite were rightly reported by a majority of the respondents as part of development of dental materials in nanodentistry. A finding that is similar to a report among dental students [17,19]. This may be because Nanohybrid and nanofilled resin-based composites are readily available types of composite restorative materials and nanoparticles have been utilised extensively in composite resin [1]. Similarly, the phase-down of dental amalgam use and the clamour for its alternatives may have enhanced the knowledge and use of composite resins among dentists.

Nano particles in composite were reported by the respondents in this study to improve aesthetic property of the material by making it more translucent and improve/modify its wear properties. This finding may be because composite is a frequently used restorative material and it has been reported that the physical properties of nanofilled composites are higher than conventional microfilled composites [21] with improvement in aesthetics and wear properties noted [1].

The report by respondents in this study that nanometersized powders for the production of ceramic monolith causes improvement inaesthetic, wear propertiesand maximize the strength of ceramic is in agreement with a previous report by Neel., *et al*. [1].

The nanofillers and nano gels listed (Zirconica Hydroxyl Apatite, Colloidal Silica, Barium aluminosilicate nanofiller, Reactive nanogels and Bioactive calcium/sodium phosphosilicate) by respondents in this study are similar to the nanoparticles reportedly used in dentistry [22].

Although, researchers have showed an increased interest in nanotechnology; they are particularly concerned about the area of dental implants as it is believed that nanoparticles will have an impact on host responses at both cellular and tissue levels [23]; the level of awareness regarding the role of nanoparticles in dental implant was low among respondents in this study. This may be related to the non-provision of dental implant treatment to patients at the study centre.

The respondents in this study seemed fairly knowledgeable about the various applications of preventive nanodentistry; this may be attributed to the well acknowledged role of nanotechnology in the prevention and management of dental diseases [18]. However, about half of the respondents in this study recognised the use of nanorobots; a proportion that is higher than previously reported among dental students and interns [19].

The proportion (69.1%) of respondents that were aware of the use of nanodentistry in drug delivery was far higher than the 13.7% reported in a previous study [19]. This difference can be attributed to the knowledge and experience of the study participants compared to dental students and interns in the previous study.

Conclusion

The overall level of knowledge and awareness of nanodentistry among the study population was fair with the knowledge of its application in dental material science high. Continuous education on the applications of nanoparticles in all aspects of dentistry will go a long way to improve the knowledge and awareness of nanodentistry.

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