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THE AWARENESS OF ECO-FRIENDLY DENTISTRY AMONG EGYPTIAN DENTAL PRACTITIONERS: A CROSS-SECTIONAL STUDY

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ABSTRACT

Background: Dental health care is keen to promote human oral health. In order to achieve such goal, dentists use different materials and instruments and produce biomedical wastes which propose threatening challenges to the environmental balance. To oppose these ill-effects, the term "Eco-friendly Dentistry or Green Dentistry" has been established to prevent pollution and achieve sustainability.

Aim of the study: This study was done to determine the awareness of Eco-friendly dentistry among dental health care practitioners in Egypt in preparation for future implementation.

Materials and methods: A cross-sectional online survey was conducted involving 380 Egyptian dentists distributed across different geographic regions in Egypt. The survey consisted of 41 questions to assess knowledge, attitude and practicing of Eco-friendly dentistry. The collected data were analyzed with SPSS V25 IBM Inc. by using logistic regression and liner regression and $p<0.05$ was fixed as the level of significance.

Results: The results showed that 248 dentists had heard before the term "green dentistry", 115 dentists heard about it for the first time and only 19 dentists already practicing it. Moreover, the Egyptian dentists believed that the main factor for adoption of green dentistry in Egypt was knowledge (301), then cost (57) dentists and finally the time (24).

Conclusion: The scientific knowledge of the Egyptian dentists regarding green dentistry is good enough. However, the economic barriers may be a problem about its application.

KEYWORDS: Eco-friendly dentistry, Green dentistry, Egyptian dentists, Biomedical waste, questionnaire.

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INTRODUCTION

The misbehaviors of the mankind toward the mother nature resulted in critical environmental changes that forced the United Nations to adopt 17 sustainable developmental goals which became of outmost important due to environmental issues.[1] Current climate change crisis is caused by human actions that generate greenhouse gases, resulting in rising temperatures, fires, heat waves, droughts, and warming waters.[2] Sustainable development aims to achieve the needs of the present generations without compromising the needs of the future generations.[3,4]

Dental practice negatively affects the nature either by developing biomedical wastes that poison environment, or high water and energy consumption. Therefore, term "Eco-friendly dentistry" has been developed in order to achieve the sustainability within the dental field. Green dentistry is another terminology that aims to achieve an Eco-friendly environment. [3,5]

Many models have been suggested to facilitate going Eco-friendly dentistry. The most commonly used is the 4Rs model. This model consists of four modules to perform the green dentistry in dental clinics. These modules are "Rethink, Reduce, Reuse and Recycle". Rethink module involves the orientation of the dentists and patients toward green dentistry. Reduce module aims to increase the availability of resources. Reuse module targeting to substitute the disposable items with reuseable products. Finaly, Recycle module which aims to transform the wastes to new useable items.[6–11]

Other researchers tried to facilitate the practicing of green dentistry through establishing practical steps. **Velaparambil** and **Gupta**[10] suggested four practical ways to go green. First way is the properly manage of the developed dental wastes. Secondly is conservation of the energy and dental clinic. Third way is shifting to recent high technology in dentistry and finally replacing the chemical agent with environmentally safer herbal alternatives.

Zia et al., in 2024 reviewed many literatures discussing Eco-friendly dentistry and they found that all of them were sharing six themes to study this topic. The six themes are amalgam management, radiography management, infection control management, procurement management, energy and water conservation.[4]

Knowledge, attitude and practices (KAP) surveys are widely accepted researching method in the public health field for searching health-related behaviors. It is a quantitative process that is commonly used to assess newly situations. KAP studies have the advantages of simplicity of designing, conducting, analyzing and interpreting. Moreover, KAP survey is characterized by straightforward, low budget and easily targeting accessible population.[12]

Therefore, this work aimed to determine the awareness of Egyptian dental health care professionals regarding the Eco-friendly dentistry in the Egyptian dental clinics by KAP survey to determine the baseline level of their knowledge, attitude and practicing of Eco-friendly dentistry.

MATERIALS & METHODS

Sample size calculation:

Sample size calculation was determined using Raosoft® tool according to Cochran's formula with the following data; population size was set as 67571 which was the number of working dentists registered at the Egyptian dental syndicate at year 2022. The confidence level was set at 95% with a margin of error 5% .[13]

Study Design and population:

A cross-sectional, self-administered online survey was conducted to assess the awareness of the Egyptian dental practitioners from all Egyptian territories about the green dentistry and measures the level of practicing of the green dentistry. The survey followed Strengthening the Reporting of

Observational Studies in Epidemiology (STROBE) checklist for observational studies.[14]

Study methods and questionnaire:

After reviewing similar studies [15,16], a structured English language questionnaire composed of 41 close-ended questions divided into 3 parts was designed. The first part collected the geographic distribution of the practitioners, the second part gather the scientific degree, academic certificate and years of dentistry practicing and the last part assess the Knowledge, attitude and practices of the participants.

Survey Validity:

A pilot study was performed and the survey was pre-tested before the beginning of its dissemination among small sample of dental colleagues to test the length of the questionnaire and identify any language or structure issues or any unclear questions. Three questions were more clarified and one question was omitted considering the received feedback and after that, the final version of the questionnaire was confirmed.

Collecting data:

The questionnaire was transformed to an electronical form by adding its questions to Microsoft form tool. The questions were randomized for each response. Selection of the respondents were randomized by following stratified random type of sampling using Microsoft Excel. The questionnaire was sent electronically to the respondents through WhatsApp application. After one week, the responses were analyzed to check reaching the required responses according to geographical areas. Another randomization and sending the questionnaire were performed to the geographical areas that do not reach the required responses.

Inclusion criteria: The study included the Egyptian dentists practicing dentistry in Egypt under the age of 60 years.

Exclusion criteria: The study excluded the dentists who refused to participate in the study, non-Egyptian dentists and participants above 60 years.

Ethical Considerations:

The protocol of this study has been registered and exempted by Institutional Review Board Organization IORG0010868, Faculty of Oral & Dental Medicine, Ahram Canadian University submitted on 10/9/2023. Study participants received detailed information regarding the purpose of the study and informed that they have the right to withdraw from the study at any time without facing any consequent harm.

Statistical analysis:

The data was collected in Excel Sheet exported from the Microsoft forms, Data was analyzed with IBM SPSS Statistics (Armonk, New York, USA), version 25 for Windows. Statistical difference between the variables was tested by using logistic regression analysis to test the binary dependent variables and liner regression analysis was performed when analyzing more than two dependent variables. The level of significance was set at $p<0.05$.

RESULTS

The geographic distribution of the survey responds followed to a very close percent the distribution of the active Egyptian dentists' distribution provided from the Egyptian dental syndicate (Table 1). The participants scientific degree reported 172 graduate dentist and 139 dentists with post-graduate certificates and 71 register to post graduate programs. Moreover, 238 of the participants are holding a bachelor degree, 97 holding master degree and only 48 holding PhD degree. In addition, 172 of the participants are practicing dentistry less than 5 years, 139 practicing dentistry more than 10 years and 71 dentists practicing dentistry from 5-10 years (Table 2).

TABLE (1) The geographic distribution of the participants.

1.	Number of Responses	Research percent	Syndicate percent
Central area	144	37.7%	37.29%
West of Delta	61	15.97%	15.85%
East of Delta	71	18.59%	18.72%
Center of Delta	65	17.02%	17.23%
North upper Egypt	19	4.97%	5.09%
South upper Egypt	22	5.76%	5.77%
Total	382	100%	

The results of the responds to the questions regarding knowledge, attitude and practices of green dentistry were represented in table 3. Most questions discussing the knowledge reported a very good knowledge of the Egyptian dentist about the green dentistry and its positive impact on the environment (q 5,6,8,9,10,11,12,13). Regarding the attitude of the Egyptian dentists toward the green dentistry, the answers showed good responses to some aspects such as shifting to digital dentistry energy and water saving and wastes disposal. However, the practicing of green dentistry reported fair results in some issues such as using plants (q 7) disposal of fixers (q 22), using computer recording systems (q 23) mercury and dental amalgams (q 36), and using formocresol (q 41). Nevertheless, other results reported a good practicing regarding green dentistry such as energy saving (q 33,34), water saving (q 38,39), proper waste disposal (q 35).

TABLE (2) Distribution of participants details.

2. Scientific degree:		
Graduated	Post graduate student	Post graduated
172	71	139
3. The highest academic certificate:		
Bachelor degree	Master degree	Doctoral degree
238	96	48
4. Years of Dentistry Practicing:		
Less than 5 years	5-10 years	More than 10 years
172	71	139

TABLE (3) Responses to questionnaire by participants.

	CA	WD	ED	CD	NU	SU	Total	P value	SC (Relation)
5. Are you aware of the term green dentistry?									
Heard before	123	44	41	26	7	7	248 (64.92 %)		
Heard for first time	13	13	28	36	11	14	115 (30.10 %)	0.000 *	0.321 (weak)
practicing it	8	4	2	3	1	1	19 (4.97 %)		
6. Do you think green practice plays a role in environmental conservation?									
Yes	91	37	48	36	8	9	229 (59.95 %)		
No	5	3	3	4	2	2	19 (4.97 %)	0.054	
May be	48	21	20	25	9	11	134 (35.08 %)		
7. Do you use plants in your clinic to increase oxygenation?									
Yes	59	17	15	13	5	6	115 (30.10 %)	0.004 *	0.149 (weak)
No	85	44	56	52	14	16	267 (69.90 %)		

8. Do you think we should shift to more environment suitable supplies?									
Yes	130	52	59	54	14	16	325 (85.08 %)		
No	3	2	3	2	2	2	14 (3.66 %)	0.015 *	0.125 (weak)
May be	11	7	9	9	3	4	43 (11.26 %)		
9. Do you think shifting to green Practice will be more economical to the dentists?									
Yes	68	24	31	30	9	10	172 (45.03 %)		
No	18	9	11	8	3	3	52 (13.61 %)	0.983	
May be	58	28	29	27	7	9	158 (41.36 %)		
10. The green practice requires minimal resources and no additional cost of basic infrastructure									
Yes	78	29	35	35	9	10	196 (51.31 %)		
No	6	3	5	3	1	1	19 (4.97 %)	0.551	
May be	60	29	31	27	9	11	167 (43.72 %)		
11. Do you think Eco-friendly dentistry be universally recommended?									
Yes	91	45	51	49	13	14	263 (68.85 %)		
No	2	1	2	2	1	1	9 (2.36 %)	0.207	
May be	51	15	18	14	5	7	110 (28.80 %)		
12. Do you think increasing the awareness among people about environment will let patient in future might select providers based on their green practice?									
Agree	103	46	53	51	14	15	282 (73.82 %)		
Disagree	4	2	3	2	1	2	14 (3.66 %)	0.514	
Not sure	37	13	15	12	4	5	86 (22.51 %)		
13. What are the factors that are influencing the adoption of green dentistry?									
Cost	19	11	10	8	4	5	57 (14.92 %)		
knowledge	115	46	57	53	14	16	301 (78.80 %)	0.354	
Time	10	4	4	4	1	1	24 (6.28 %)		
14. Before switching over to green practice, I would test the adoption on a small scale and products compatible with the green practice									
Agree	126	44	52	45	13	16	296 (77.49 %)		
Disagree	2	2	2	2	1	1	10 (2.62 %)	0.004 *	0.148 (weak)
Not sure	16	15	17	18	5	5	76 (19.90 %)		
15. Do you know that environmental pollution could lead to cleft lip and palate in newborn children?									
Yes	77	35	40	35	11	12	210 (54.97 %)	0.052	
No	67	26	31	30	8	10	172 (45.03 %)		
16. Do you know that environmental pollution could lead to early childhood caries?									
Yes	92	38	43	39	12	14	238 (62.30 %)	0.000*	0.605 (medium)
No	52	23	28	26	7	8	144 (37.70 %)		
17. Do you know that environmental pollution could lead to Molar incisor hypomineralization?									
Yes	112	42	45	39	13	16	267 (69.90 %)	0.000*	0.431 (weak)
No	32	19	26	26	6	6	115 (30.10 %)		
18. What should be the preferred type of flooring?									
Vinyl	48	16	21	12	7	6	110 (28.80 %)		
Polyvinyl chloride	77	34	41	41	10	12	215 (56.28 %)	0.255	
Linoleum/cork	19	11	9	12	2	4	57 (14.92 %)		

19. Do you agree to promote reusable metal air/water syringes & suction devices, biodegradable cups?									
Yes	77	40	47	42	10	13	229 (59.95 %)		
No	56	15	17	15	6	6	115 (30.10 %)	0.921	
May be	11	6	7	8	3	3	38 (9.95 %)		
20. Do you thing Digital Radiographs are more green practice friendly than Conventional Radiographs									
Yes	126	52	60	53	12	12	315 (82.46 %)		
No	6	3	3	4	2	1	19 (4.97 %)	0.000*	0.202 (weak)
May be	12	6	8	8	5	9	48 (12.57 %)		
21. Should we go digital to eliminate photochemical waste?									
Yes	129	50	58	58	11	14	320 (83.77 %)		
No	7	4	6	4	4	4	29 (7.59 %)	0.004*	0.145 (weak)
May be	8	7	7	3	4	4	33 (8.64 %)		
22. Do you recycle the fixer and developer solution?									
Yes	29	9	4	3	1	2	48 (12.57 %)		
No	90	41	51	47	16	18	263 (68.85 %)	0.063	
Sometimes	25	11	16	15	2	2	71 (18.59 %)		
23. Do you use computer-based record system for paper waste management?									
Yes	92	32	30	19	6	7	186 (48.69 %)		
No	36	20	29	34	11	13	143 (37.43 %)	0.000*	0.199 (weak)
Sometimes	16	9	12	12	2	2	53 (13.87 %)		
24. Do you think Dental office infection control and sterilization processes can be a major source of a waste generation & pollution?									
Yes	120	29	31	28	8	8	224 (58.64 %)		
No	7	9	13	14	7	7	57 (14.92 %)	0.000*	0.274 (weak)
May be	17	23	27	23	4	7	101 (26.44 %)		
25. Do you use Tree oil/thyme/natural disinfecting agents as a surface disinfectant in the clinic?									
Yes	41	19	17	18	2	3	100 (26.18 %)		
No	83	20	27	32	14	15	191 (50.00 %)	0.082	
Sometimes	20	22	27	15	3	4	91 (23.82 %)		
26. Do you use cloth instruments wrap over paper & plastic autoclave bags for the steam sterilization?									
Yes	94	34	35	31	6	5	205 (53.66 %)		
No	35	18	24	23	9	10	119 (31.15 %)	0.000*	0.223 (weak)
Sometimes	15	9	12	11	4	7	58 (15.18 %)		
27. The average number of autoclave bags used per day:									
Less than 10 bags	38	13	14	11	2	3	81 (21.20 %)		
10-20 bags	92	36	40	29	12	11	220 (57.59 %)	0.000*	0.221 (weak)
More than 20 bags	14	12	17	25	5	8	81 (21.20 %)		
28. What type of lab coats and patient drapes is being used in your practice?									
Reusable	49	27	29	21	1	2	129 (33.77 %)		
Disposable	23	11	7	9	3	4	57 (14.92 %)	0.006*	0.139 (weak)
Both	72	23	35	35	15	16	196 (51.31 %)		

29. Do you use disposable cups?									
Yes	136	58	70	64	19	21	368 (96.34 %)	0.000*	0.038 (weak)
No	8	3	1	1	0	1	14 (3.66 %)		
30. The average number of patient bibs used per day:									
> 5 bibs	33	11	7	8	1	2	62 (16.23 %)		
5-10 bibs	74	31	36	32	9	9	191 (50.00 %)	0.000*	0.189 (weak)
< 10 bibs	37	19	28	25	9	11	129 (33.77 %)		
31. Do you use sterilizable instruments like trays, film holding devices rather than disposable products?									
Yes	125	38	54	46	9	10	282 (73.82 %)		
No	8	10	10	12	2	1	43 (11.26 %)	0.000*	0.254 (weak)
Sometimes	11	13	7	7	8	11	57 (14.92 %)		
32. Is energy management beneficial in green dental practice?									
Yes	89	42	44	42	10	12	239 (62.57 %)		
No	8	4	2	3	1	1	19 (4.97 %)	0.432	
I don't know	47	15	25	20	8	9	124 (32.46 %)		
33. What do you use for energy management?									
incandescent light bulbs	32	26	17	20	7	8	110 (28.80 %)		
LED light bulbs/CFI	92	21	51	44	12	14	234 (61.26 %)	0.002*	-0.159 (weak)
Motion light sensors	20	14	3	1	0	0	38 (9.95 %)		
34. Do you unplug all electric appliances after use?									
Yes	83	36	43	27	11	15	215 (56.28 %)		
No	27	14	15	13	3	4	76 (19.90 %)	0.56	
Sometimes	34	11	13	25	5	3	91 (23.82 %)		
35. Do you follow proper waste disposal method in clinic?									
Yes	124	47	41	38	8	9	267 (69.90 %)		
No	7	3	4	6	6	8	34 (8.90 %)	0.000*	0.283 (weak)
Sometimes	13	11	26	21	5	5	81 (21.20 %)		
36. Where do you dispose of mercury?									
In liquid	3	9	7	9	0	1	29 (7.59 %)		
In garbage	2	5	22	25	13	14	81 (21.20 %)	0.000*	-0.482 (weak)
Both	11	6	17	10	1	2	47 (12.30 %)		
not using amalgam	128	41	25	21	5	5	225 (58.90 %)		
37. What do you use as an alternative to amalgam filling?									
CR	119	45	58	47	13	14	296 (77.49 %)		
GIC	10	6	6	11	2	3	38 (9.95 %)	0.116	
RMGIC	8	4	5	6	3	3	29 (7.59 %)		
CER	7	6	2	1	1	2	19 (4.97 %)		
38. What type of dental vacuum pump do you use?									
Dry	97	42	40	39	11	15	244 (63.87 %)	0.000*	0.566 (medium)
Wet	47	19	31	26	8	7	138 (36.13 %)		

39. Do you reduce water wastage during hand washing?									
Yes	67	27	36	37	10	9	186 (48.69 %)		
No	21	8	9	7	1	2	48 (12.57 %)	0.749	
Sometimes	56	26	26	21	8	11	148 (38.74 %)		
40. Do you use water faucets sensors in clinic?									
Yes	64	34	11	7	1	2	119 (31.15 %)	0.000*	2.21 (strong)
No	80	27	60	58	18	20	263 (68.85 %)		
41. Could you stop using formocresol in your clinic and shift to other alternatives?									
Yes	69	24	32	35	5	7	172 (45.03 %)		
No	33	12	21	15	7	7	95 (24.87 %)	0.607	
May be	42	25	18	15	7	8	115 (30.10 %)		

CA: Central area, WD: West of Delta, ED: East of Delta, CD: central of Delta, NU: North Upper Egypt, SU: South Upper Egypt, SC: Standard coefficient, CR: Composite resin, GIC: Glass ionomer cement, RMGIC; resin modified glass ionomer cement, CER; Ceramic inlay/onlay

****: Represents a statistically significant difference between the different geographic areas at P-value < 0.05.***

DISCUSSION

The term Green and Eco-friendly implies the use of an alternative source of energy, renewability, non-toxic material, efficient use of energy and fewer carbon footprints. Eco-friendly or green dentistry could become truth by effectively designing dental clinics and using more Eco-friendly materials in the clinical practice.[17]

In order to increase the promotion of Eco-friendly dentistry, **Vanka** et al., in 2018 suggested 4 A's protocol; Ask, Assess, Advice and Assist. Therefore, this work was designed as a first step in the way to turn the dentistry in Egypt to an Eco-friendly practice. The questionnaire achieved the first step (Ask) and the study tried to achieve the second step (Assess) and prepared an Advice (third step) that may lead to last step (Assist).[18]

This study firstly collected the data of the Egyptian dentists from the Egyptian dental syndicate. The collected questionnaires followed the geographical distribution of the working dentists. Moreover, the questionnaires contain different scientific degrees and years of dental practice in an attempt to gain a realistic data about dental Egyptian society. The questionnaire followed the 4Rs model in its questions with concentrating mainly on the "Rethink" parameter.

The results of the present study found that the Egyptian dentists have heard the term (green dentistry). Moreover, they believe in shifting toward the green practice due to its effective role in conservation of the surrounding environment.

Rethink

The strategy of change is based mainly on thinking. Redeveloping a mindset concerned with environmental sustainability leads to orientation towards practicing of Eco-friendly dentistry as a daily routine.[6,8,11]

In the present study 64.92% dental practitioners heard the term green dentistry before, 30.10% dentists heard for the first time and 4.97% dentists are currently practicing it. This indicates that there is a need to evolve our current practice into Eco-friendly practice overall Egyptian governates. However, the majority of dentists that heard about Eco-friendly dentistry before or currently practicing it are from the central area of Egypt, there was a

weak relation between the degree of awareness and geographic distribution. Nevertheless, only 4.97% of the participants don't think that green practice plays a role in environmental conservation and 3.66 % thinks that we shouldn't shift to more environmental suitable supplies. Moreover, there was only 2.36% who don't think that Eco-friendly dentistry be universally recommended. In addition, the questionnaire revealed that 78.80% of the respondent dentists think that knowledge is the influencing factor for the adoption of green dentistry in Egypt.

Moreover, the results of the questionnaire revealed a good knowledge about the pollution effect on early childhood caries and molars hypo-mineralization. On the other hand, there was a lack of proper knowledge about the effect of pollution on cleft lip and palate in newborn.

Therefore, from the results of the questions related to the "Rethink" module, it can be concluded that the Egyptian dental society have a good background about the green dentistry and believes in the green dentistry to save the planet.

Reduce

It is the simplest module in order to apply green dentistry. Reducing the usage of the resources leads to preventing depletion of natural resources in addition to reducing the resultant wastes.[3]

The current paper discussed the "Reduce" module through different aspects. Firstly: Reducing the usage of energy. Reducing energy consumption in the dental clinics leads to reduce the cost and decrease the carbon emissions.[19,20] Energy can be reduced with slightly easy procedures such as changing the incandescent lamps with LED lamps, using motion light sensors and unplug electric devices after use.

LED lamps conserve 70% of energy compared to halogen lamps[6] and produce 70% less heat.[11] The lower evolved heat will positively affect the cooling efficiency of the air conditioners and subsequently reduce the electricity consumed by air conditioners. Shutting down or put the computers to sleep or stand-by mode reduces the electricity used by 70%.[11]

The current work assessed the application of the previously mentioned procedures by Egyptian dentists. The results reported that only 4.97% of respondents don't think that energy management beneficial in green dental practice while 32.46 % don't have the information and 62.57 % believe in the role of energy management on the green dentistry. Moreover, 61.26 % of participants are using LED lights in their clinics. Unfortunately, there is only 9.95% uses motion light sensors. In addition, unplugging the electrical appliances after use reported unsatisfactory results as 56.28% of participants reported unplugging the electric devices after use, 23.82% unplug them sometimes and 19.90 % left the electric devices on after use.

According to the previous results, it gives us an indication about the importance of increasing the awareness about the importance of using motion light sensors, changing to LED lamps and unplugging electric devices after use.

Water conservation can be achieved through using waterless vacuum system and decreasing the water wastage during hand and instruments washing. Wet vacuum systems can use up to 60 gallons of water per day.[11,21]

The present survey found that 63.87% of participants use dry vacuum systems, 48.69 % of them reduce water wastage during hand washing in addition to 38.74% of them sometimes reduce that water wastage. Regrettably, only 31.15% of respondents uses water faucet sensors in clinic to control the water wastage during hand and instrument washing. Therefore, the preservation of water should be a priority in the way to achieving green dentistry in the Egyptian dental society.

Paper reduction can be performed by changing to digital recording systems to record patients' data.

This transformation saves the environment from using more paper. It is worth mentioning that 35% of trees cut are used for paper manufacturing. The forests are the main way to get rid of carbon dioxide "the most harmful gas of all greenhouse gases".[22]

The dentists also achieve some direct benefits such as saving money used for purchasing papers, save places used for archiving patients' files and allow easy recalling these data without risk of paper damage with time.

The results of the present study reported that 48.69% of the respondent dentists use computer-based recording systems, while 13.87% are sometimes depend on those electronic systems. On the other hand, 37.43% are not using electronic recording systems. The current work recommend collaboration between dental syndicate or ministry of health with the civil society organizations to fund a free licensed electronic patient recording system. This program may be designed as a graduation project of any computer programming faculties.

Changing to digital dentistry plays an important role in "Reduce" module. Digital dentistry includes digital radiography, digital impressions and digital patients recording methods.

Using digital radiographs reduces the amount of conventional x-ray films with its plastic, lead and paper components in addition to no need for using developer and fixer solutions. Fixer solution contains a high content of the silver in the form of silver thiosulphate. The silver content is approximately 4000 mg per liter.[3,10]

Moreover, the unused dental films contain high content of unreacted silver. Conventional radiographs require using of lead inside the film package and as shields for the operator. The lead is considered as a hazardous waste that can be leached and contaminate the soil and groundwater.[3,6]

However, digital radiographs provide the dentist with an instantaneous image with higher quality with lesser radiation dose than conventional type.[6]

The present study revealed the change to digital radiography by Egyptian dental community. The survey showed that there was a good awareness about the benefits of digital radiograph over conventional mode. 82.46% of the participants think that digital radiographs are more Eco-friendly practice than conventional radiographs. Moreover, 83.77 % of the participants believe in the role of digital radiography in the elimination of photochemical wastes of conventional radiography. Regrettably, the survey found that 68.85% of the respondents do not recycle the fixer and developer solutions. The results of the present work recommend encouraging the dentists to change to digital radiography.

The chemicals used for sterilization can release volatile organic compounds (VOC). These VOC have harmful effects over the working personnels and the patients due to poor office air quality. Changing to steam sterilization results in eliminating the chemical-based sterilization. Changing the chemical compounds used for disinfecting the surfaces and non-steam sterilizable materials with herbal solutions is a very effective method to avoid the harmful effect of chemical compounds.[6,11,23]

The results of the present work showed that 50.00% of the respondents don't use natural disinfectants for surface disinfection. Only 26.18% use the natural materials in order to disinfect the surfaces, 23.82% sometimes use natural materials for disinfection procedures. Consequently, this result recommends increase the awareness to the hazards of chemical disinfectants and the effect of natural substitutes.

Formocresol is used in endodontics and pedodontics as tissue fixative and antibacterial agent. However, the cytotoxicity and carcinogenicity of formaldehyde, leads the researchers to find more natural and safer alternatives. Formocresol had an impact on eyes, neurological system and upper respiratory tract with 0.05 part per million (PPM).

In higher doses, it harms the lower respiratory system. It can be lethal at 20 PPM.[24,25] The current survey reported that 24.87% of the participants will neither stop using formocresol nor shift to other alternatives. However, 45.03% of the participants will shift the use of formocresol to other alternatives and 24.87% of the participants may follow that safer shift. Therefore, the current result recommends increasing the awareness of the Egyptian dentists to the danger of formocresol and the efficiency of its alternatives.

The present survey showed a respectable response regarding waste disposal method in the clinics. 69.90% of respondents reported a proper disposal of the wastes and 21.20% sometimes dispose the wastes properly. On the other hand, only 8.90% don't dispose the wastes properly.

Reuse

This module concerns with replacing the single use disposable items with a sterilizable multiuse substitutes. This reduces the demand of the resources required for manufacturing the disposable items with subsequently decreasing energy used for manufacturing them. In addition, the replacing of single use plastics, such as suction tips, patient and chair drapes and water cup, results in decrease the plastic wastage. The petroleum-derived plastics are not biodegradable wastes and ends up in the landfills.[3,11]

The present work assessed the transformation to using many reusable things. The use of cloth wrap instead of paper and plastic bags was performed by 53.66% of the respondents with 15.18% using cloth wrap sometimes, while 31.15% still using paper and plastic wraps. Moreover, 33.77% of the participants reported using the usage of reusable lab coats and patient drapes, 14.92% reported to use disposable lab coats and patient drapes while 51.31% used both of them.

Regarding using disposable plastic cups, 96.34% of the respondents stated using disposable cups. Only 3.66 % don't use them. In addition, 73.82% of the participants reported using metallic trays and film holding devices rather than plastic products and 14.92% sometimes using metallic alternatives, while only 11.26% using plastics.

The current survey revealed that 58.64% of the respondents thinks that the dental office infection control and sterilization processes are a major source of a waste generation and pollution and 26.44% think that they may be the source of waste generation and pollution causative factors while 14.92% don't think that.

Moreover, the results of the current study revealed an interesting finding which is regarding the equipment not used directly by patients, such as trays, film holder and sterilization wraps, the replacing with reusable alternatives is high, while the rinsing cups, which are used directly by the patients, are disposable. Therefore, the current work suggests changing to a biodegradable plastic rinsing cups as the patients will refuse to use a metallic or ceramic cup used by another patient even if it is sterilized.

Recycle

The last module in the 4Rs model discussed in the present paper is "Recycle". Recycling enhances the sustainability by reducing the amount of wastes end in landfills and by limiting the use of the resources.[3]

Dental amalgam wastes should be separated from the dental clinic wastes due to its health hazard. Dental amalgam consists from about 50% mercury in addition to silver, tin and other metals. Mercury is a highly toxic element that can be released in the form of ions or vapors and can be easily absorbed by the human lung alveoli into blood stream. Mercury is a neurotoxic and nephrotoxic.[3,6,8]

The results of the present study revealed promising results about changing to amalgam-free dentistry. The current survey showed that 58.90% of the respondents are not using dental amalgams in their clinic and replaced them with resin composite

restorations (77.49%). On the other hand, there were disappointing results about the method of disposing mercury; 21.20% dispose it in garbage, 7.59% in water and 12.30% on both garbage and liquid.

The future of green dentistry in Egyptian dental society

Velaparambil and **Gupta**[10] proposed that the barriers against the shifting to green dentistry are the sufficient knowledge and the initial cost. The sufficient knowledge was discussed previously in the current work. Regarding the cost, the survey discussed the relation between the cost and the willingness of the Egyptian dentists.

Cost

In the present study, 45.03% of the respondents found that shifting to Eco-friendly dentistry will be more economical to the dentist and 41.36% thinks that green practicing may be more economical to dentists. On the other hand, only 13.61% don't believe in the economic effect during green practicing.

Moreover, 51.31% of the participants thought that the green practice requires minimal resources and no additional cost of basic infrastructure. 43.72% thinks that green practicing may require minimal resources and no additional cost. On the other hand, only 4.97% believe that green practicing required additional cost.

In addition, the present survey reported that most participants (73.82%) believe that patients may select the dental health care provider according to their green practicing, 22.51% not sure and only 3.66% don't believe in selecting their dentists regarding their green practicing.

From the previous results, the current study found that the cost is not considered a main barrier against the first step toward shifting to dental practicing particularly 77.49% of the participants tends to start green practicing in a small scale.

The relation between geographic areas and the responses to the questionnaire

Finally, the geographical distribution regarding the responds in the questions of the current survey reported no relation in 16 questions, weak relation in 18 questions, medium relation in only 2 questions and strong relation in only 1 question. This indicates that the knowledge and tend of Egyptian dental society throughout the different territories are nearly the same.

Limitations of the study

To the point of writing this study, there are no published studies assessing the knowledge and perception of green dentistry among Egyptian dental practitioners which limited comparing the results as only the published studies are in other countries with different cultural and economic concerns, the point that will bias the comparison of the current results.

CONCLUSION

The transition to utilizing green dentistry in Egypt is dependent upon educating the Egyptian dentists its concepts and methods specially as they are keen for its application. However, the economic barriers are standing as problem about its application.

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