



Awareness and Knowledge of Dental Personnel on the Role of Internet of Things (IoT) in Dentistry- An Online Survey.

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ABSTRACT

Introduction: The bulk of the science and technology sections are breached with Internet of Things (IoT) applications in different forms. Unless the dentist having thorough knowledge on the new technology and smart gadgets, it is not possible to provide better and accurate treatment services to the patients even if they are using the technology-based applications in their clinical practice.

Aim: The aim of the present study was to gather detailed first-hand information from dental personnel about their awareness and how much knowledge they have on Internet of Things (IoT) applications in the dental field.

Study Design: A cross-sectional, descriptive survey was conducted using google forms with 12 questions were put forwarded to the dental personnel through various social media.

Place and Duration of Study: The validated and pretested questionnaire was sent to dental teaching faculty, dental practitioners, post graduate students and interns, from 5th June 2023 to 4th July 2023 across various dental teaching institutes in Andhra Pradesh.

Methodology: A total of 292 responses were received. The collected data was transferred on to the Microsoft Excel Sheet and the descriptive statistical analysis was done by using Statistical Package for Social Sciences (SPSS) 26 (SPSS Inc., Chicago, IL, USA).

Results: A total of 293 responses were obtained but 16 responses were rejected as they were submitted after 5th July 2023. Males participated more in number (162) compare with females (130), and among all the participants, the involvement of teaching faculty (113) was more in number, and the role of intern number (32) was less.

Conclusion: Out of 292 responses, most of the participants were not having knowledge about Internet of Things (IoT) applications in dentistry, whereas more than 50% aware of IoT applications in general.

Key words: Internet of Things (IoT), Internet of Dental Things (IoDT), Dental Applications, Dental Sensors, Smart applications in dentistry.

INTRODUCTION

There is a tremendous change occurring during last decade both in medical and dental fields. Recently one of the technologies which is spreading its tentacles very fast in medical and dental health care sector is Internet of Things (IoT). The Internet of Things (IoT) is also known as Internet of Dental Things (IoDT) [1,2]. IoDT, is composed of internet, objects and public attached together with digital technology. The working mechanism of IoT in dentistry is physical, virtual and cloud, the physical world includes, smart phones, wearables and sensors using in dentistry, comes under physical objects. The virtual type includes the devices which are connected to internet, information connects from these devices, and finally the cloud, which contains computer process system which will manage the data sent by the network connected appliances [2,3].

If the patient using any disease tracking device which contains a sensor, the recorded data information will be communicated to the patient mobile phone or other communication

devices through sensors and in turn this information forms a network called 'BAN (Body Area Network) stored in the cloud for analysing and diagnosis purpose [4]. Few of the dental clinicians already applying different IoT based applications in their practice and tasting the success which includes, smart tooth brushes [3-6] , Smart dental implants [7] ,Spot the implants [8], Tooth-Mounted Diet Sensors [2] Wearable biosensor system [1,2], Smart mouth guards [9], RFID Sensors [10], Teledentistry [11,12], and Artificial intelligence (AI) [13]. The latest arsenal is 'digital twins [14].

Past one decade the usage of IoT based devices, services, equipment in health sector going in slow phase, but from the post covid the momentum picking in the health care field in full swing [2,15] .There are very few research studies and review articles were documented in the literature about the applications of Internet of Things (IoT), Whereas no literature is available on the dental personnel who are aware about IoT and having sufficient knowledge to apply the latest technologies in their day-to-day dental practices. Hence this cross -sectional descriptive survey study aimed to assess the awareness and knowledge of dentists on the applications of various Internet of Things (IoT) related applications and equipment available for dental treatments.

METHODOLOGY

Study Design: Descriptive Cross-sectional study

Study Population: Dental personnel including Teaching faculty, Post graduate students, Practicing Dentists and Interns across Andhra Pradesh.

Sampling Criteria: Purposive Sampling

Study Instrument: The self-administered questionnaire used in the present study was adopted from a previously published study [16]. For the collection of online data, one of the exemplary tools "Google forms" were used, which have many advantages such as participant's identity will not be revealed along with these forms assess and provide the instant statistics to the researcher to grasp the interpretation, the participants can fill the

google form with privacy and comfortably even using their smart phones also and finally, These google forms will not allow any tracking of the answers given by the participant.

For the questionnaire affirmation:

1. A qualified and skilled person was involved in the preparation of the questionnaire.
2. After discussing the fellow dental clinicians the face validity of the questionnaire was established.
3. A pilot study was conducted randomly among different dental personnel.

Twelve questions were put forwarded to dental teaching faculty, dental practitioners, post graduate students and interns, from 5th June 2023 to 4th July 2023, and a total of 292 dental personnel were responded for this web-based cross-sectional study.

Questionnaire

1ST SET- Demographic Details

1. Gender---- male/ female
2. Designation: Teaching faculty, Post Graduate Students, Practicing Dentists and Interns

2ND SET- Participants Awareness on the role of Internet of Things (Iot) in Dentistry:

4. Are you aware of Internet of Things (Iot) in general?
5. Are you aware that Internet of Things (Iot) using in dentistry?
6. Are you aware that Internet of Things (Iot) using sensor-based applications?
7. Are you aware of Internet of Things (Iot) based Dental toothbrushes are available in the market?

3RD SET: Participants Knowledge on the role of Internet of Things (Iot) in Dentistry:

8. Do you know that smart dental implants integrated with Internet of Things (Iot) to monitor their performance by the clinicians?

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9. Do you know about IoT-enabled dental equipment, such as chairs, X-ray machines, and dental drills, can be connected to a network, allowing for better control and monitoring.?

10. Do you know that IoT can enable predictive maintenance of dental equipment by monitoring usage patterns and detecting potential failures before they occur.?

11. Do you know that IoT facilitates remote consultations and telemedicine in dentistry.?

12. Do you know that tooth-mounted sensor can track patient diet information to such as glucose, salt, and alcohol intake etc?

STATISTICAL ANALYSIS

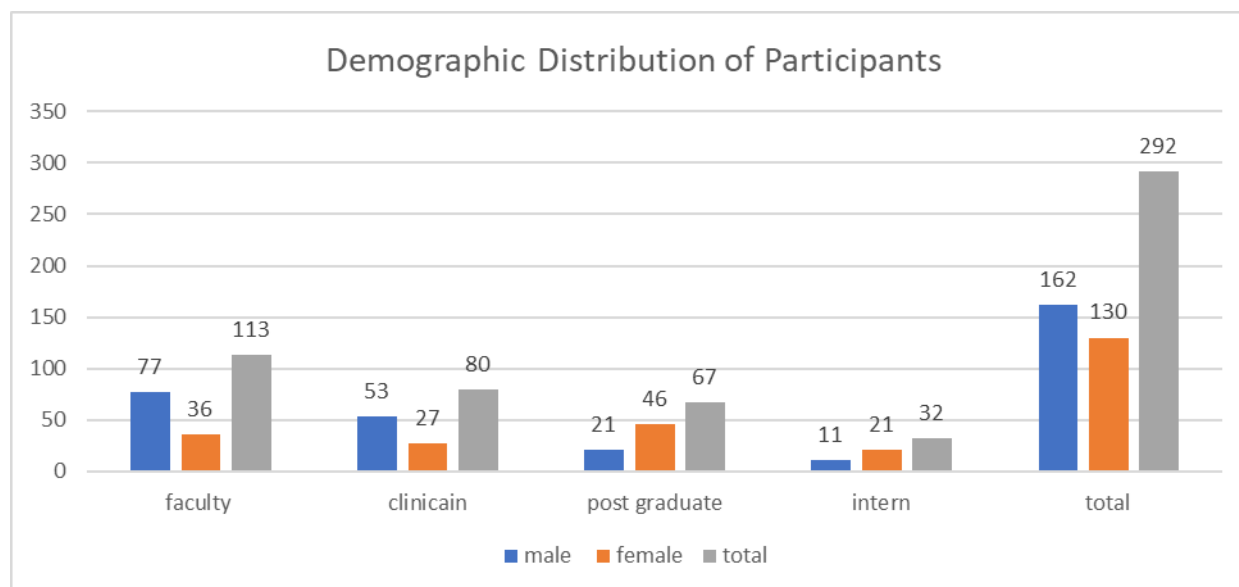
The collected data was transferred on to the Microsoft Excel Sheet and the descriptive statistical analysis was done by using Statistical Package for Social Sciences (SPSS) 26 (SPSS Inc., Chicago, IL, USA). Chi-square distribution was implemented for categorical variables. P value ≤ 0.05 is considered statistically significant.

Ethical consideration:

The institutional ethics committee approval was obtained prior to the study initiation (File No.04/IEC/LIDS/2023/Faculty, Dt: 29/04/2023).

RESULTS

Graph-1: shows the distribution of 292 participants, based on gender and designation. Among the participants, 162 were males and 130 were females. Designation distribution reveals that dental teaching faculty (113) were more than Clinicians (80), Post Graduate Students (67) and Interns (32). Males were more predominant in the faculty (77) than females (36). Female postgraduate students (46) are more than males (21).



Graph 1: Demographic Distribution of Participants

Table 1: shows the frequency of responses from the 292 participants. Regarding the Internet of Things (IoT) in general, there is a huge percentage of participants (74%) were aware of it. Whereas an equally good number of participants (69.2%) were aware of IoT using in dentistry. First full of participants (96.6%) were aware of IoT using Sensor-based applications in the dentistry, but half of the participants (50.3%) were not aware of IoT-based dental toothbrushes that are available in the market. 61.6% of the respondents reported of not having knowledge on IoT based smart dental implants integrated to monitor their performance by the clinicians. Whereas more than fifty percentage of the participants (53.8%) had knowledge regarding better control and monitoring of IoT-based equipment such as dental chairs, X-ray machines and dental drills connected through a network. 55.8% of participants had a knowledge of telemedicine in dentistry. Finally, a huge percentage of participants (68.2%) reported not having knowledge on IoT-based tooth-mounted sensors to track patient dietary information.

SNo	Question	Yes (%)	No (%)
1	Are you Aware of Internet of Things (IoT) in General	216(74)	76(26)

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2	Are you aware that Internet of Things (IoT) using in Dentistry?	202(69.2)	90(30.8)
3	Are you aware that Internet of Things (IoT) using Sensor-based applications?	177(60.6)	115(39.4)
4	Are you aware of Internet of Things (IoT) based Dental toothbrushes are available in the market?	145(49.7)	147(50.3)
5	Do you know that smart dental implants integrated with Internet of Things (IoT) to monitor their performance by the clinicians?	112(38.4)	180(61.6)
6	Do you know about IoT-enabled dental equipment, such as chairs, X-ray machines, and dental drills, can be connected to a network, allowing for better control and monitoring.?	157(53.8)	135(46.2)
7	Do you know that IoT can enable predictive maintenance of dental equipment by monitoring usage patterns and detecting potential failures before they occur.?	116(39.7)	176(60.3)
8	Do you know that IoT facilitates remote consultations and telemedicine in dentistry?	163(55.8)	129(44.2)
9	Do you know that tooth-mounted sensor can track patient diet information to such as glucose, salt, and alcohol intake etc?	93(31.8)	199(68.2)

Table 1: Frequency Distribution of Responses from the Participants

Table 2: shows the distribution of responses to awareness of the participants according to their profession in the role of the Internet of Things (IoT) in Dentistry. In relation to the awareness of participants about the Internet of Things (IoT), the maximum number of Dental teaching faculty (92) were aware of it, followed by Practicing Dentists/Clinicians (62), Post Graduate students (49) and minimum from the intern group (13). statistically significance was observed [$P \leq 0.05$]. Regarding the awareness of the participants' designation wise on IoT using in Dentistry, dental teaching faculty stood first (83) followed by Practicing Dentists (63), Post Graduate students (41) and the interns in last position (15). The results obtained were highly significant statistically [$P = 0.003$]. The respondents who were aware about IoT-based Sensor applications, took first place by the teaching faculty (69), second place by the practicing Dentists (56), third place by Post Graduate students (37) and least was with interns

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(15). No statistical significance was observed [P=0.098]. Awareness about the availability of IoT-based dental toothbrushes in the market, 57 teaching faculty were not aware of it followed by Post Graduate students (39), practicing dentists (34) and finally 17 interns. The results obtained were statistically not significant [P=0.293].

Responses from the participants		Teaching Faculty	Practicing Dentists	Post Graduate Students	Interns	Chi-Square	P-Value
Are you Aware of Internet of Things (IoT) in General	Yes	92	62	49	13	22.276	.000
	No	21	18	18	19		
Are you aware that Internet of Things (IoT) using in Dentistry?	Yes	83	63	41	15	13.874	.003*
	No	30	17	26	17		
Are you aware that Internet of Things (IoT) using Sensor-based applications?	Yes	69	56	37	15	6.307	.098
	No	44	24	30	17		
Are you aware of Internet of Things (IoT) based Dental toothbrushes are available in the market?	Yes	56	46	28	15	3.726	.293
	No	57	34	39	17		

Table 2: Distribution of Responses on the awareness of the Participants according to profession wise, on the role of Internet of Things (IoT) in Dentistry.

Table 3: shows the distribution of responses of the participants about the knowledge on the role of the Internet of Things (IoT) in Dentistry, according to their profession, related to the performance of IoT-based smart implants. The clinicians can monitor the lion head share of teaching faculty (68), were not known about the information, followed by practicing dentists (56), post graduate students (36) and interns (20). There were no statistically significant results observed [P=0.236]. The knowledge about the IoT enabled dental equipment allowing

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for better control and monitoring by connecting with network, a big number of teaching faculty (61) had knowledge, followed by post graduate students (42), practicing dentists (40) and-minimum number of interns (14). The results obtained were statistically not significant [P=0.273]. A bulk number of teaching faculty (72) know about IoT based tele dentistry followed by practicing dentists (54), post graduate students (33). The results obtained were statistically highly significant [P=0.000]. A smaller number of participants had knowledge on tooth mounted sensors to track the diet of the patients, irrespective of their designations. Teaching faculty (35), practicing dentists (26), post-graduate students (23), interns (9) know about the diet sensors. There are no significant results found statistically [0.930].

Questions		Teaching Faculty	Practicing Dentists	Post Graduate Students	Interns	Chi-Square	P-Value
Do you know that smart dental implants integrated with Internet of Things (IoT) to monitor their performance by the clinicians?	Yes	45	24	31	12	4.249	.236
	No	68	56	36	20		
Do you know about IoT-enabled dental equipment, such as chairs, X-ray machines, and dental drills, can be connected to a network, allowing for better control and monitoring.?	Yes	61	40	42	14	3.895	.273
	No	52	40	25	18		
Do you know that IoT can enable predictive maintenance of dental equipment by monitoring usage patterns and detecting potential failures before they occur.?	Yes	49	26	33	8	7.087	.050*
	No	64	54	34	24		
Do you know that IoT facilitates remote consultations and telemedicine in dentistry?	Yes	72	50	36	5	25.388	.000*
	No	41	30	31	27		
Do you know that tooth-mounted sensor can track patient diet information to such as glucose, salt, and alcohol intake etc?	Yes	35	26	23	9	.450	.930
	No	78	54	44	23		

Table-3: Distribution of Responses on the Knowledge of the Participants according to profession wise, on the role of Internet of Things (IoT) in Dentistry

DISCUSSION

In the present study almost half of the participants were not aware of the IoT based applications using in the dentistry and less the half were not having knowledge about them. When the designation point of view, majority of the teaching faculty members were aware, and they know about the applications of IoT in dental health care system. This may be because they are in teaching profession and continuously acquiring the knowledge. Interns got the last position both in view of awareness as well as knowledge, may be due to their education and less experience.

There are many advantages with IoT based applications such as: (1).It is very easy to record, collect, store and share the patient data; (2).It simplifies the sharing and communication of information from the patient to dentist and vice versa, (3).Inspection of the acquired data and supervising the obtained parameters, (4).At community level, a wider way of data can track very easily, (5).Possible to take preventive measures for some of the commonly occurring oral diseases which are responsible for the result of loss of natural teeth,(6).It saves the time of patient and clinician results in providing comfort zone to the patient, and (7).Accurate results will be obtained, compare with conventional treatment procedures. The ambiguity will persist always among the clinicians if any new equipment or technology introduced. The success of the same will depend upon the positive approach of the clinicians. The clinicians should have knowledge and readily accept the technology and apply it [3].

According to Ganesh BS et al., Kaushal B et al., and Goh E et al., [3,5,6] IoT based Dental toothbrushes are embedded with sensors can reveal the pressure applied by the patient while brushing. Some of the smart brushes are incorporated with cameras, which can take the clinical pictures of the teeth condition of the patient and send the data to the dentists for

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evaluation. In the present study 50% of the participants were having no clue regarding availability of IoT incorporated Toothbrushes in the market. As per Ganesh BS et al., Tadinada A et al., and Sannino G and his colleagues, [3,7,8] osseointegration can be tracked with the help of IoT incorporated sensors attached to the smart dental implants. These sensors are called ‘Ti-PEEK Hybrid implants’ developed by Prof. Alireza Hassan Zadeh. In our present study, lion head share of the participants (61.2%) doesn’t know about these smart dental implants. Khan SA et al., and Jampani ND and his co-workers [12,17] stated that, teledentistry services can be possible to provide for the remote area population with the help of IoT based applications.

Fiorenzo Omnetto stated that, IoT based small sensors can be attached either to natural or artificial teeth of the patient, to track the type of diet consumed by the patients as well as these sensors can identify the eating disorders, food allergies and intolerances in advance, which can help the dentists to take preventive measures [3]. In the present study a huge percentage of participants [68.2%] were not having knowledge on IoT based tooth mounted sensors can track the patient diet.

Lizheng Liu and colleagues in China developed ‘iHome Dental Health-IoT system’, a home-based platform and a device to diagnose 7 different dental diseases, analyse the data and gives early alerts to the patients regarding future problems in advance [18]. According to Salagare S, and Goa W et al., both non-invasive and invasive wireless sensors will be used in the mouth for tracking purpose [2,19]. Along with implants the invasive trackers and the non-invasive trackers will be attached to the tooth or to the prosthesis both in buccal and lingual surfaces of the teeth.

Learning platforms are very much used during Covid and continuing them [20]. The latest inventory for remote learning is called DenTeach, which works on IOT enabled Digital Twins technology. According to Maddahi Y and Chen S from their case review discussed about

digital twins based new portable added value of digital twins, present a portable learning platform for remote dental education called DenTeach [14].

CONCLUSION

The present survey reveals that majority of the participants were not aware of the recent advances in dentistry, which connected through IoT based applications. The IoT in dentistry is blaring day by day. The service providers should be aware of the latest technology to provide better services to the patients.

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