

## ORIGINAL RESEARCH

## Awareness among Dental Students and Practitioners on Biohazards Associated with Prosthodontic Materials

S Narmadha Devi<sup>a</sup>, Anila Xavie PX<sup>a</sup>, Ponselkar Abraham<sup>b</sup>, Keerthi Narayan<sup>c</sup>

## ABSTRACT

**Background:** Dental practitioners are exposed to work-related risks resulting in potential injury with long-term local and systemic adverse effects that impact the overall health and quality of life. Bio-hazards from an increasing number of new prosthodontic materials remain a major problem among dental professionals concerning their safe clinical application, disposal, and recycling without causing possible environmental harm.

**Aim:** The present study was aimed to assess the awareness levels among dental students and practitioners on biohazards associated with commonly handled prosthodontic dental materials.

**Methodology:** A cross-sectional questionnaire-based online survey was conducted using Google forms distributed among dental students and professionals across Tamilnadu, India. Statistical Package for Social Sciences software (SPSS version 22.0) was used to analyze the observed data with a significance level set at less than .05 ( $p < 0.05$ ).

**Results:** 70.7% considered patients, dentists, dental assistants, and technicians working in close association with dental materials carry substantial health risks while most of the participants reported burning mouth syndrome and contact allergic reactions were frequent adverse reactions encountered. 27.3% and 50.2% were unaware of hazards associated with epoxy resins and ceramic restorations respectively besides 41.9% agreed on nickel as a potential carcinogen and 65.8% showed familiarity with biocompatibility material tests. However, 32.68% were unresponsive to chemicals with potential adverse reactions present in the glove material.

**Conclusion:** The study clearly shows that mere knowledge and familiarity with prosthodontic dental material and its biological characteristics are insufficient for an individual to assess the potential threat. Thus, an in-depth understanding of various hazardous risks will educate the dental professional for building a better work practice with enhanced personal health care.

**Keywords:** Allergic reaction, Biocompatibility, Contact dermatitis, Dental Material, Epoxy resins, Monomer.

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## INTRODUCTION

The Health hazards are potential sources of risk to a person by a material, substance, process, or situation in the working environment that either predisposes or by itself causes physical, chemical, biological, psychological, radiation, occupational and musculoskeletal effects.<sup>1</sup> Dental practitioners are frequently exposed to several health hazards and work-related risks resulting in potential injury with long-term local and systemic adverse effects that impact the overall health and quality of life.<sup>2</sup> Most clinical procedures in dentistry involve exposure to

newer materials, chemicals, blood and body fluids, or other contaminated and highly contagious substances. One such area of frequent infection and growing concerns are the prosthodontic clinics and dental prosthetic labs where a significant number of instruments and materials used for various procedures are frequently transported between the dental clinic and the laboratory, increasing the possibility of cross-contamination and other related health hazards.<sup>3,4</sup>

Literature studies have shown that more than 75% of all the existing dental materials are directly or

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indirectly used or involved when creating and providing prosthodontics restorations to be placed in the oro-facial complex of patients.<sup>5,6</sup> Early materials included rigid and semi-rigid compositions such as plaster, zinc-oxide eugenol, impression compound, and waxes; these materials still have limited uses in dentistry. Currently, advancements in newer materials in the field of prosthetics have increased concerns regarding the safe clinical application of widely used materials such as metal alloys, cement, impression materials, resin-based synthetic polymers, dental amalgam, composites, and dental ceramics of different compositions or manipulation techniques.<sup>7</sup> Some of the most common health risks include inhalation of vapors and dust particles, irritation or injury caused by chemicals, inflammable materials, allergens, high-speed rotary instruments, and hypersensitive reactions among patients, dental personnel, and laboratory technicians.<sup>8-10</sup>

On the other hand, biological hazards are one of the greatest challenges of substantial concern in the oral health care industry owing to increased microbial contamination during aerosol procedures, handling of impression contaminated by bloodborne pathogens and saliva, and dissemination of possible infectious biological substances such as bacteria, virus or toxins through salivary ejectors, suction and dental instruments that can affect human health.<sup>11-13</sup> Improper handling of these materials carries a significant risk of transmitting potential pathogens, highly infectious microbes, and nosocomial infections in patient's predominantly human immunodeficiency virus (HIV), and Hepatitis. Thus, appropriate precautions should be practiced in handling the materials and dental instruments to avoid potential hazards and prevent possible injury to the oral tissues without compromising the overall health status of an individual. Numerous clinical trials and in-vitro studies were carried out to evaluate the harmful effects of dental materials however studies focusing on assessment of awareness towards materials that cause allergic reactions, adverse effects, handling or management protocols and methods of biohazard prevention and control were very few. An extensive assessment of awareness level can be a valuable tool in formulating appropriate measures and strategies to handle these health hazards. Considering the above prospects, the present study was aimed to assess the awareness levels among dental students and practitioners on biohazards associated with prosthodontic dental materials.

## MATERIALS AND METHOD

A cross-sectional questionnaire survey was conducted amongst the dental students and professionals across Tamil Nadu, India to assess their awareness level on potential biohazards

associated with prosthodontic dental materials. The required information was collected through published scientific articles on the study and self-administered structured questionnaires, comprising of 25 questions prepared in the English language were distributed among the selected population, and responses were evaluated. The questionnaire had both combinations of selected responses to certain questions and also a few close-ended questions (Yes / No/ don't know).

A total of 205 randomly selected dental students and professionals across Tamilnadu participated in this survey. Since this study was conducted during the COVID-19 Pandemic lockdown period, online Google forms were generated and distributed through social media platforms. It was observed that the internal consistency of the questionnaire was adequate (Cronbach's alpha = 0.883). All the participants were briefed about the purpose of the study and pre-filled consent was obtained before the survey through Google forms and assured that their participation was purely voluntary. Statistical analysis was performed using SPSS version 22 (SPSS Inc., Chicago, IL, USA). Descriptive data were analyzed using frequencies and percentages. The Chi-square test was used to compare the awareness scores within the population group. All statistical tests were performed at 90% confidence intervals. The level of significance was set at  $p < 0.05$

## RESULTS

On analysis of the given data the mean age of the study population was observed as  $24.273 \pm 4.646$  years (mean  $\pm$  S.D) with 0.639 at 95% confidence level comprising 92 (44.8%) male and 113 (55.12%) female participants. It was observed that the majority of the study participants 62.24% are undergraduate dental students (128 out of 205) followed by 19.02% (39) were postgraduate students, and 18.54% (38) were dental professionals respectively. Chi-square test analysis to correlate interrelationship between the year-wise distribution of the study participant showed a chi-square statistic of 76.052 with  $p$  value  $< .0001$ . The result is significant at  $p < .05$  (Table 1).

Category of participants	Observed	Expected	Frequency N (%)	Difference	Difference Sq.	Diff. Sq. / Exp Fr.
Undergraduate	128	69	62.44%	59.00	3481.00	50.45
Postgraduate	39	68	19.02%	-29.00	841.00	12.37
Private Practitioner	38	68	18.54%	-30.00	900.00	13.24

The Chi<sup>2</sup> value is 76.052. The p-value is  $< .0001$ . The result is significant at  $p < .05$ .

Table 1: Distribution frequency of the study participants

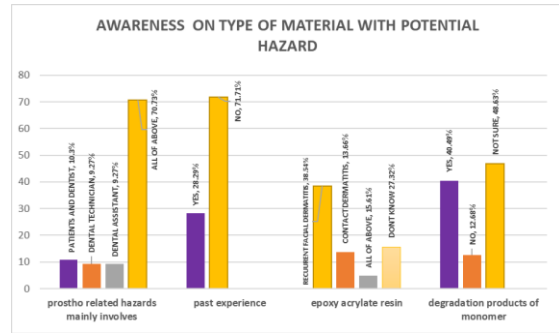
### Interpretation of the survey (Table 2):

In the present study it was observed 70.7% considered patients, dentists, dental assistants as well as technicians working near dental materials carry health hazard risks among which 71.7% have

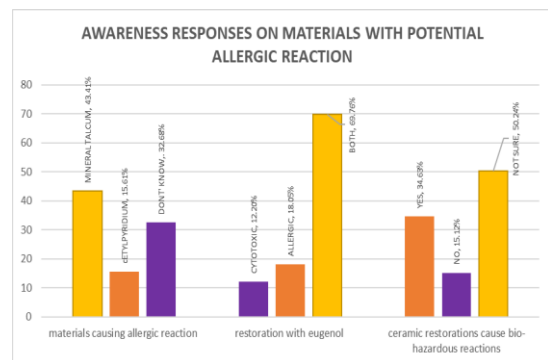
S no:	Questions	Options	Responses N (%)	p-value
1.	Are you aware of biocompatibility tests are available to minimize the risk of adverse effects?	Yes	135 (65.85)	<.0001*
		No	37 (18.05)	
		Don't know	33 (16.10)	
2.	Are you aware that accidentally splashed pumice in the eyes can cause eye abrasion?	Yes	105 (51.22)	<.0001*
		No	37 (18.05)	
		Maybe	63 (30.73)	
3.	The use of epoxy acrylate bisphenol-A glycididimethacrylate in dental works is known to cause	Recurrent Facial Dermatitis	79 (38.54)	<.0001*
		Contact dermatitis	28 (13.66)	
		Lichen planus	10 (4.88)	
		All of the above	32 (15.61)	
		None of the above	56 (27.32)	
		Mineral Talcum	89 (43.41)	
4.	Which chemical used in gloves is known to cause irritation?	Corn starch	17 (8.29)	<.0001*
		Cetylpyridium chloride	32 (15.61)	
		Don't know	67 (32.68)	
		Patent and dentist	22 (65.85)	
5.	Prosthetic hazards may affect mostly	Dental technician	19 (65.85)	<.0001*
		Dental assistant	19 (65.85)	
		All of the above	145 (65.85)	
		None of the above	145 (65.85)	
6.	Are you aware of pneumoconiosis?	Yes	146 (65.85)	<.0001*
		No	59 (65.85)	
		Dentist	49 (65.85)	
7.	Do you know who is more prone to pneumoconiosis?	Patient	26 (65.85)	<.0001*
		Technician	107 (65.85)	
		Assistant	23 (65.85)	
8.	Grinding and polishing with vibrating tools can cause	Vibration symptom of hand	17 (65.85)	<.0001*
		Vibration white finger	19 (65.85)	
		Injury to face and upper extremities	26 (65.85)	
		All of the above	143 (65.85)	
9.	What is Eugenol?	Cytotoxic	25 (65.85)	<.0001*
		Allergic substances	37 (65.85)	
		Both	143 (65.85)	
10.	Do you think ceramic restorations can cause allergic reactions in some individuals?	Yes	71 (65.85)	.004*
		No	31 (65.85)	
		Not sure	103 (65.85)	
11.	What are the biocompatibility tests available to minimize the risk of adverse reactions to dental materials?	Cell culture tests	14 (65.85)	<.0001*
		Hemolytic tests	13 (65.85)	
		System toxicity tests	31 (65.85)	
		All of the above	147 (65.85)	
12.	Is formaldehyde, a degradation product of various monomers used in dentistry?	Yes	83 (65.85)	<.0001*
		No	26 (65.85)	
		Not sure	96 (65.85)	
13.	Do you know which is the most common side effect of prosthetic materials is	Type I	26 (65.85)	<.0001*
		Type II	45 (65.85)	
		Type III	34 (65.85)	
		Type IV	100 (65.85)	
		Transient Redness	22 (65.85)	
14.	What do you think are frequent dermatological reactions seen in hypersensitivity to materials?	Irritation	29 (65.85)	<.0001*
		Pain	19 (65.85)	
		All of the above	135 (65.85)	
		Damage to eyes	22 (65.85)	
15.	What are the Non- Dermatological Reactions commonly seen?	Respiratory Reactions	29 (65.85)	.0038*
		All	137 (65.85)	
		Chromium	33 (65.85)	
16.	Which metal do you think might cause allergic reactions?	Cobalt Nickel	57 (65.85)	<.0001*
		Gold	27 (65.85)	
		Ni-Ti	64 (65.85)	
		None	24 (65.85)	
		Denture Adhesives	38 (65.85)	
17.	The most common reason for allergic reaction associated with the use of	Denture Cleansers	76 (65.85)	<.0001*
		All of the above	50 (65.85)	
		Don't know	41 (65.85)	
		Contact with Skin	39 (65.85)	
18.	Patient might experience adverse effects due to	Exposure to dust from grinding and polishing	59 (65.85)	<.0001*
		Inhalation of fumes and vapors	67 (65.85)	
		None of the above	40 (65.85)	
19.	What are the adverse reactions associated with prosthetic treatment?	Burning mouth syndrome	20 (65.85)	.0065*
		Contact Allergic reaction	24 (65.85)	
		All of the above	143 (65.85)	
		Others	18 (65.85)	
20.	Are you aware that acrylic monomer inhalation can cause "Acute Respiratory Distress Syndrome"?	Yes	137 (65.85)	.0077*
		No	68 (65.85)	
21.	Which of the following is a carcinogen?	Nickel	86 (65.85)	<.0001*
		Titanium	27 (65.85)	
		Mercury	73 (65.85)	
		Copper	19 (65.85)	
22.	Have you ever experienced any allergic reaction from dental materials?	Yes	58 (65.85)	<.0001*
		No	147 (65.85)	
23.	Materials left in inaccessible areas of oral cavity affects cell viability	True	156 (65.85)	<.0001*
		False	49 (65.85)	
24.	What do you do when your bare hands are exposed to eugenol?	Clean hands with dry cotton and gauze	48 (65.85)	<.0001*
		Wash hands with soap and water	92 (65.85)	
		Wash hands with only water	52 (65.85)	
		None of the above	13 (65.85)	
25.	Methyl methacrylate (MMA) monomer may result in toxic reactions and allergic responses in previously sensitized individuals	Yes	169 (65.85)	<.0001*
		No	36 (65.85)	

Table 2: Responses obtained for each question evaluated under the study

never experienced any allergic reaction from dental materials. On evaluation of awareness towards the type of materials with potential hazards, only 38.53% agree with use of epoxy acrylate bisphenol-A-glycididimethacrylate causing recurrent facial dermatitis whereas 46.8% are not sure about various degradation products in monomers used in dentistry and 27.3% were unaware of hazards associated with epoxy resins. The majority of the participants believe denture adhesives and cleansers also have potential hazards (Graph 1).

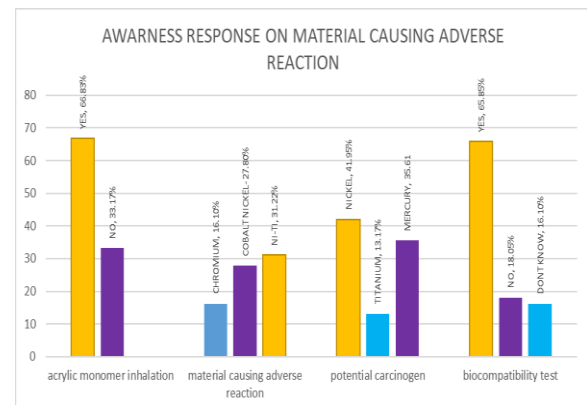


Graph 1: Awareness responses on type of material with potential hazard



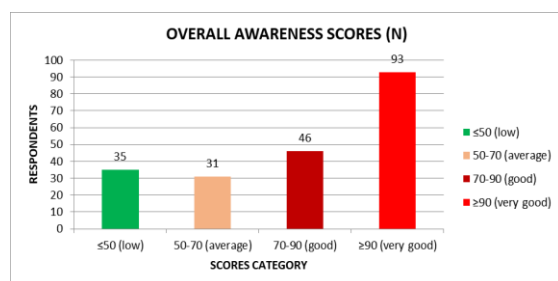
Graph 2: Awareness responses on type of material with potential allergic reaction

On assessment of responses on materials causing allergic reactions only 43.41% identify mineral talcum as a known material with irritable nature while 32.68% were not familiar with chemicals with potential adverse reactions present in the glove material. Majority of respondents (69.76%) are aware that restoration with eugenol causes both cytotoxic and allergic reaction and recommends washing hands with soap and water is sufficient to prevent complications however 50.24% were not sure ceramic restorations can cause bio-hazardous reactions (Graph 2).



Graph 3: Awareness responses materials causing adverse reaction

66.8% are aware acrylic monomer inhalation causes acute respiratory distress syndrome and 31.2% replied that Nickel-titanium, and cobalt-nickel metals (27.8%) are frequently associated with allergic reactions among which 41.9% consider nickel as a potential carcinogen. 65.85% were aware of biocompatibility tests available to detect or minimize adverse reactions among which 71.7% are familiar with cell culture tests, hemolytic tests and system toxicity tests commonly used for biocompatibility testing (Graph 3). Burning mouth syndrome and contact allergic reactions are the most frequent adverse reactions associated with prosthodontic material. 65.85% believe transient redness, irritation and pain are the most frequent dermatological reactions seen in hypersensitivity to materials and 66.82% responded damage to the eyes, respiratory reactions are the other uncommon non-dermatological reaction. 69.5% of the respondents are aware of adverse effects caused by grinding and polishing with vibrating tools among which 51.21% are agrees that accidental splashed pumice in the eyes can cause eye abrasion during polishing. It was also illustrated that 71.21% are familiar with pneumoconiosis among which 52.1% knew technicians are more prone to get affected. In the final analysis, the assessment of overall awareness scores based on correct responses (Table 3) and associations between the percentages and the respondent revealed 72.17% of study participants had adequate awareness towards biohazards associated with prosthodontic materials (Graph 4).



Graph 4: Overall Mean awareness score obtained by the study participants based on the distribution

Overall Score	Awareness responses	X <sup>2</sup>	p value
≤50 (low)	35 (17.07)	126.453	<0.0001*
50-70 (average)	31 (15.12)		
70-90 (good)	46 (22.43)		
≥90 (very good)	93 (45.36)		
total	205 (100.00)		
median score	72.17		

\*P<.05 – Significant level; X<sup>2</sup>- Chi-square value

Table 3: Frequency of correct responses and the Mean awareness score obtained by the study participants

## DISCUSSION

Materials like metal alloys, resin-based synthetic polymers, polymer materials, dental cements, etchants, denture adhesives, cleansers, sealers,

impression materials, and dental ceramics are widely used in clinical prosthodontic practice and for the fabrication of dental prosthesis by technicians as well as dental practitioners in day to day life.<sup>14</sup> Rajan R et al,<sup>1</sup> Singh RD et al,<sup>15</sup> Tippat et al,<sup>16</sup> Mattoo K et al<sup>17</sup> in their respective studies observed gypsum and its byproducts, investment materials, alginate, dental alloys containing gold releases hydrogen sulfide gases and other potentially toxic elements that deteriorates properties of the soil as a result of dumping grounds/land fillers, incineration, and sewage sludge incineration hence recommends recycling and effective reuse of dental materials. The lack of knowledge about recycling and reuse of these materials might be associated with a very low importance and emphasis given on these topics during curriculum-based undergraduate dental course training.

In the present study Majority (69.5%) of the respondents are aware of adverse effects caused by grinding and polishing with vibrating tools and also agree increased prevalence of accidentally splashed pumice in the eyes causes eye abrasion during polishing. Kumar et al,<sup>18</sup> Szymanska et al,<sup>19</sup> and Tillberg et al<sup>20</sup> claimed that the effects of vibration on the hand can result in white finger syndrome or vibration syndrome due to narrowing of the end arteries in fingers and hands. Similarly Szymanska et al,<sup>19</sup> Farrier SL,<sup>21</sup> and Gasyna et al<sup>22</sup> also reported the use of pumice containing lime or quartz and high-speed cutting tools during grinding and polishing causes corneal effects ranging from mild irritation through corneal abrasion. Halawani R et al,<sup>14</sup> and Alshiddi IF<sup>23</sup> recommend the use of protective aprons/gowns, shatter-resistant eyeglasses, and head caps, splash guards, safety guards for lathes-cutting tools along with routine use of gloves and face masks/shields.

Resins associated with skin reactions due to direct contact prevail for a longer duration resulting in irreversible tissue reactions. These resin-based materials contain inert and insoluble materials such as amines, copolymers butyl-methacrylate, dibutyl-phthalate as plasticizing agents and hydroquinone-containing inhibitors. 38.53% agree use of epoxy acrylate bisphenol-A-glycididimethacrylate causes recurrent facial dermatitis. Our results were in agreement with studies by Safa'a AA et al,<sup>3</sup> Padmaja S et al.<sup>7</sup> Kumar et al,<sup>18</sup> Szymanska et al,<sup>19</sup> and Kim TS et al<sup>24</sup> showed painful irritation, allergic effects are elicited by resin materials. In this study about 27.3% were unaware of hazards associated with epoxy resins and 46.8% are not sure about the degradation products of various monomers used in dentistry. Studies have shown that resin vapors at more than 125ppm in the working environment may cause corneal irritation, sore throat, and cough.<sup>18</sup> Thus, the amounts of leachable components play an important role in the occurrence of toxic responses ranging from mild to severe reactions.

Direct skin contact causes itching, burning, redness, swelling and cracking of the skin. Causes tingling, numbness or whitening of the skin. Nervous system symptoms are headache, drowsiness, nausea, weakness, fatigue, irritability and dizziness. However, the initiation of an allergic reaction in a sensitized individual requires minimal amounts of the allergen to be present. If frequent or prolonged skin contact with resin is necessary then use of gloves, goggles or face shield should be recommended. Contact allergic reactions (type IV reactions) are the most common biological side effects of prosthodontic materials.<sup>7,25</sup> These results also show us that more knowledge about resin-based materials should be incorporated into dental students.

Burning mouth syndrome and contact allergic reactions are the most frequent adverse reactions associated with prosthodontic material. Self-cure resins can facilitate soft tissue irritation in some individuals, resulting in a syndrome called burning mouth syndrome. Shivakumar et al,<sup>10</sup> Samyuktha et al,<sup>26</sup> Rai R et al,<sup>27</sup> Gosavi SS et al<sup>28</sup> demonstrated burning sensation may result from direct mucosal irritation, intraoral manipulation of resin or because of the presence of residual monomer. We observed that 71.21% are familiar with pneumoconiosis among which 52.1% knew technicians are more prone to get affected. Ceramic materials are generally regarded as inert, but dust particles containing free silica materials arising during handling, manipulating, adjusting, and finishing the fabrication represent a potential problem, both for the laboratory and clinical personnel as well as patients. NIOSH recommends an exposure limit of 0.05 mg/m<sup>3</sup> for such dust particles with potential harm. OSHA reported the occurrence of chronic illness among dental laboratory technicians and, advised implementing precautions to minimize exposure to silica-containing dust particles.<sup>29, 30</sup> It is argued that the risk of air-borne particulate exposure is higher during casting process among dental technicians in the absence of acceptable exhaust, adequate fume extraction systems, filtration systems, aerosol/dust evacuation hood and personal protective equipment. Substitution with safer materials and use of airtight containers is also recommended to reduce the risk.<sup>7,10,25,29</sup> Hence improper handling of these materials could be hazardous to the health of dental personnel.

On assessment of responses on materials causing allergic reactions only 43.41% identify mineral talcum as an irritating agent while 32.68% were not familiar with chemicals used in gloves. Latex gloves dusted with cornstarch powder, an allergen with irritant potential are more often used in dental practice. Natural latex, synthetic rubber, and synthetic polymeric glove materials also show varying cytotoxicity as a result silicone, powder-free gloves, nitrile or polyvinyl gloves were introduced

to reduce the risk.<sup>25-29</sup> Eugenol is one of the most cytotoxic and allergic substances known in dental practice. Eugenol acid (a weak acid) is a potent irritant that is known to cause redness and blisters on the skin.<sup>20</sup> Majority of respondents are aware that restoration with eugenol causes both cytotoxic and allergic reaction and recommends washing hands with soap and water is sufficient to prevent complications.

Metal alloys predominantly nickel and chromium exposed during casting, fabrication and finishing of metal reinforced restoration and frameworks carry potential carcinogenic effects on dentists and technicians.<sup>7-10</sup> Leakage and transfer of potentially allergic components from such materials carry the risk of hypersensitive reactions. About 31.2% in our study agreed Nickel-titanium, and cobalt-nickel metals are frequently associated with allergic reactions among which 41.9% consider nickel as a potential carcinogen. 65.8% were aware of biocompatibility tests available to detect or minimize adverse reaction among which 71.7% are familiar with cell culture tests, hemolytic tests and system toxicity tests commonly used for biocompatibility testing. Specially designed appliances for testing prosthodontic materials have not received widespread use, probably because of the inherent problems with the test or the cost involved.

#### **Limitations:**

Various synthetic and natural materials including alloys, resin polymers, gypsum products, ceramic and eugenol-containing substances have been utilized in clinical prosthodontic practice and in the laboratory during fabrication procedures. Practically it is not always possible to include all the materials used in prosthodontics. Further studies restricted to specific materials such as impression materials, Die materials, and luting agents are needed to establish their potentially hazardous nature. Irrespective of the usage and prevalence in practice, the majority of these materials have local and systemic effects ranging from mild irritation to immunologic reaction and even carcinogenesis over a prolonged period of exposure.

#### **CONCLUSION**

Within the limitations of the study, it can be argued that the degree of risk depends on several factors such as age, personal susceptibility, average daily exposure, frequency and duration of material in contact, exposure measured quantitatively over the years, and medications. Mere knowledge of commonly handled prosthodontic materials and familiarity with their characteristics is not sufficient for an individual to assess the potential threat. Understanding the various risk will educate the professional to create a better work practice and care for personal health thus improving the quality of life.

**CONFLICT OF INTEREST**

There is no conflict of interest

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