



## **Knowledge and Awareness about Food Carcinogens among Dental Students**

**A. Trishala<sup>1</sup>, Dhanraj Ganapathy<sup>2\*</sup> and Revathi Duraiswamy<sup>2</sup>**

<sup>1</sup>Saveetha Dental College and Hospitals, Saveetha Institute of Medical and Technical Sciences, Saveetha University, Chennai, India.

<sup>2</sup>Department of Prosthodontics, Saveetha Dental College and Hospitals, Saveetha Institute of Medical and Technical Sciences, Saveetha University, Chennai, India.

### **Authors' contributions**

*This work was carried out in collaboration among all authors. All authors contributed equally to the design and implementation of the research, analysis of the results and to the writing of the manuscript. All authors read and approved the final manuscript.*

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### **ABSTRACT**

The risk of developing cancer from carcinogens occurring in food is of widespread interest to scientific researchers, food policymakers, and food surveillance institutions, as well as to the general public. The aim of this study was to assess the knowledge and awareness of food carcinogens among dental students. A structured self-assessed online questionnaire having 15 questions on food carcinogens was prepared and distributed to the dental students who have clinical exposure including 3rd BDS, final BDS, interns, and postgraduates of all specialties. It was circulated using online software, a survey planet, and the response was collected through it. Statistical analysis was done using SPSS software. Considering the responses, it can be interpreted that the knowledge regarding food carcinogens is above average among dental students. Also, postgraduate students were more knowledgeable than undergraduate students. Interns showed more awareness than third-year or final year undergraduate students. Educational workshops, conferences, and CDE's are essential for both undergraduates and postgraduates to improve their knowledge regarding various carcinogenic properties of different food items.

*Keywords: Awareness; cancer; carcinogens; dental students; food.*

## 1. INTRODUCTION

Cancer is now a major cause of mortality throughout the world. Approximately 90% of all cancer cases correlate with environmental factors, including one's dietary habits [1]. The specific causes of cancer are still not fully understood. Scientists agree that most cancers are linked to lifestyle. A healthy lifestyle and diet are more appropriate for winning the war against cancer. Lifestyle modification can effectively control risk factors of cancer and lower the incidence [2].

Nutrition and dietary carcinogens relevant to carcinogenesis can be grossly divided into two categories, (i) microcomponents and (ii) macro components and total calorie intake [3]. From the mechanistic view, there are genotoxic agents causing genetic alterations related to carcinogenesis and constituents inducing tumor promotion-associated phenomena. Genotoxic agents are clearly defined as causing DNA damage resulting in gene point mutations, deletions and insertions, recombinations, rearrangements, and amplification, as well as chromosomal aberrations [4].

Dietary tumor promoters are less distinctly defined in terms of their modes of action, but, generally speaking, they cause cell proliferation with or without accompanying chronic cell damage [5]. Although tumor promoters represented by 12-O-tetradecanoylphorbol-13-acetate (TPA) exert their actions as microcomponents, most nutritional and dietary tumor promoters are of the macro component type [6]. These include fat for breast and colon carcinogenesis and sodium chloride for gastric carcinogenesis [7].

Carcinogenic processes are understood to involve multiple steps. It can be readily appreciated that, in the body of a healthy human, there are many cells that already have genetic alterations of cancer-related genes caused by various genotoxic substances, including dietary carcinogens [8]. Moreover, genomic instability, frequently resulting from mutations in genes, encoding proteins related to DNA repair would be expected to be produced by mutational events [9]. If a mutation occurs in the genes, more rapid accumulation of additional gene alterations would be yielded in other cancer-related genes [10]. Therefore, the potential contribution of minute

amounts of mutagens/carcinogens present in the diet cannot be overlooked with regard to the significance of carcinogenesis [11].

As much as 40% of all cancer deaths can be prevented by avoiding known risk factors causing cancer. There is sufficient literature that suggests that measures like risk identification, prevention, and early detection can help us achieve substantial control over the rapidly increasing burden of cancer [12]. The goal of cancer awareness campaigns is to raise the public's "brand awareness" for cancer causes, cancer early detection, and other reliable prevention measures [13]. Considering the importance of the identification of food carcinogens, this study evaluates the level of awareness among dental students.

Previously our department has published extensive research on various aspects of prosthetic dentistry [14–24], this vast research experience has inspired us to research about the knowledge and awareness about food carcinogens among dental students.

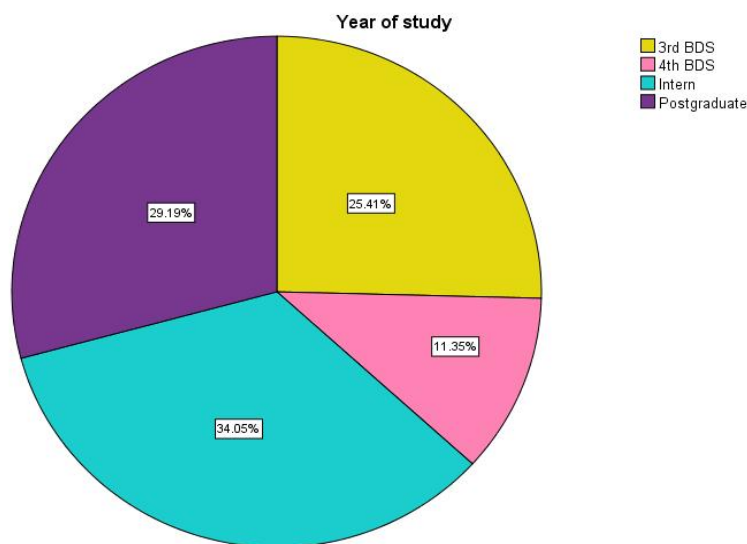
## 2. MATERIALS AND METHODS

The present study is an online-based survey conducted among dental students of a University. The number of people involved in this study includes the guide, reviewer, and principal investigator. A structured self-assessed online questionnaire having 15 questions on food carcinogens was prepared with the aim to assess the awareness among 185 dental students. The questions were validated and reviewed closely. Sampling was done by convenient sampling. The questionnaires were distributed to the dental students who have clinical exposure including 3rd BDS, final BDS, interns, and postgraduates of all specialties. It was circulated using an online link from the survey planet and the response was collected through it. Only the completed surveys were included for analysis. The collected results were entered in Microsoft Excel and statistical analysis was done using SPSS software (IBM SPSS Statistics 20.0). Frequency distribution of each response among the dental students and Chi-square association using Pearson correlation with a level of significance set at  $p < 0.05$  was done to determine the association between the year of study and the responses for each question to assess any difference in awareness and perception based on the year of study.

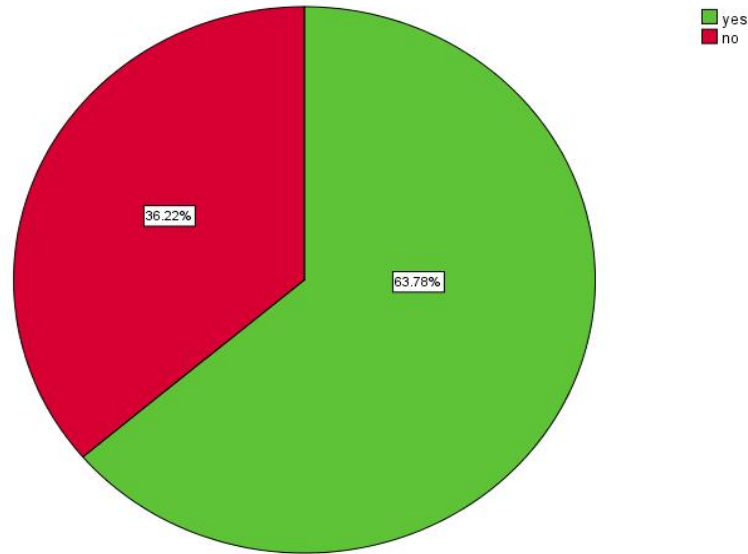
### 3. RESULTS

The study was conducted among 185 dental students. Out of 185, 25.41% were third-year undergraduate students, 11.35% were final year undergraduate students, 34.05% were interns and 29.19% were postgraduates [Fig. 1]. About 63.78% of students were aware that smoke condensates derived from grilling fish or meat exhibited potent carcinogenic activity [Fig. 2]. Among them, 23.24% were postgraduates, 19.46% were interns, 6.49% were final year students and 14.59% were third-year students. There was no significant association ( $p=0.401$ ) between the year of study and the response to the question, 'Are you aware that smoke condensates derived from grilling fish or meat exhibited potent carcinogenic activity?' [Fig. 3]. About 41.08% of students were aware that food that may be contaminated with aflatoxin B1 induced hepatic carcinoma in many species of experimental animals [Fig. 4]. Among them, 16.22% were postgraduates, 12.43% were interns, 3.24% were final year students and 9.19% were third-year students. There was no significant association ( $p=0.701$ ) between the year of study and the response to the question, 'Are you aware that food that may be contaminated with aflatoxin B1 induced hepatic carcinoma in many species of experimental animals?' [Fig. 5]. About 29.19% of students were aware that Norsesquiterpene glucoside from bracken fern was associated with tumors of

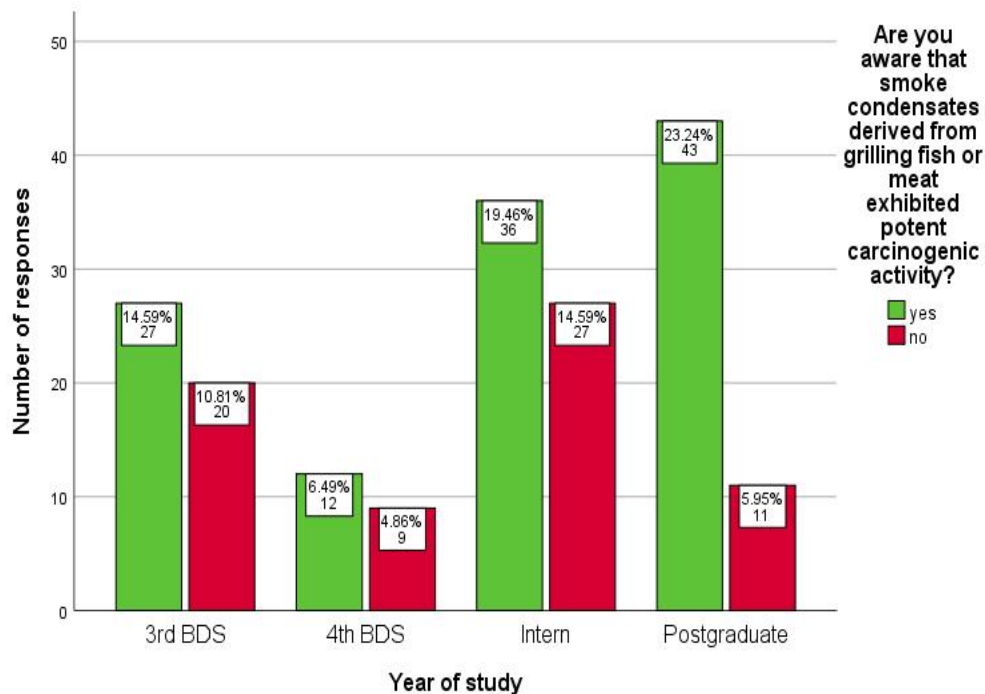
the urinary bladder [Fig. 6]. Among them, 11.35% were postgraduates, 9.73% were interns, 1.62% were final year students and 6.49% were third-year students. There was no significant association ( $p=0.170$ ) between the year of study and the response to the question, 'Are you aware that Norsesquiterpene glucoside from bracken fern was associated with tumors of the urinary bladder?' [Fig. 7]. About 41.08% of students were aware that pyrrolizidine alkaloids present in edible plants have been known to be carcinogenic in rodents [Fig. 8]. Among them, 15.68% were postgraduates, 13.51% were interns, 3.78% were final year students and 8.11% were third-year students. There was no significant association ( $p=0.124$ ) between the year of study and the response for the question, 'Are you aware that pyrrolizidine alkaloids present in edible plants have been known to be carcinogenic in rodents?' [Fig. 9]. About 47.57% of students were aware that the breakdown products of hydrazine compounds from cultivated mushrooms, 'Agaricus bisporus' is known to be carcinogenic [Fig. 10]. Among them, 17.3% were postgraduates, 16.22% were interns, 4.86% were final year students and 9.19% were third-year students. There was no significant association ( $p=0.133$ ) between the year of study and the response for the question, 'Are you aware that the breakdown products of hydrazine compounds from cultivated mushrooms, 'Agaricus bisporus' is known to be carcinogenic?' [Fig. 11].



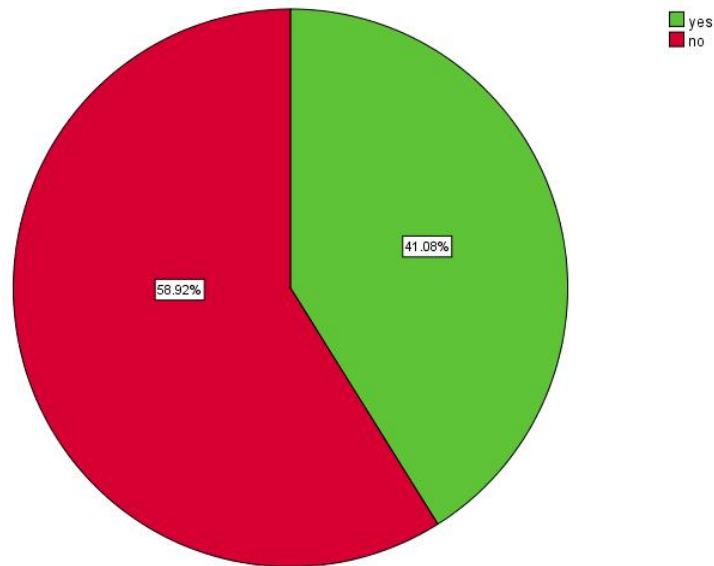
**Fig. 1.** Pie chart represents the year of study of dental students included in this study. The majority of the study population were interns (34.05%), followed by postgraduates (29.19%), third-year students (25.41%), and final year students (11.35%)



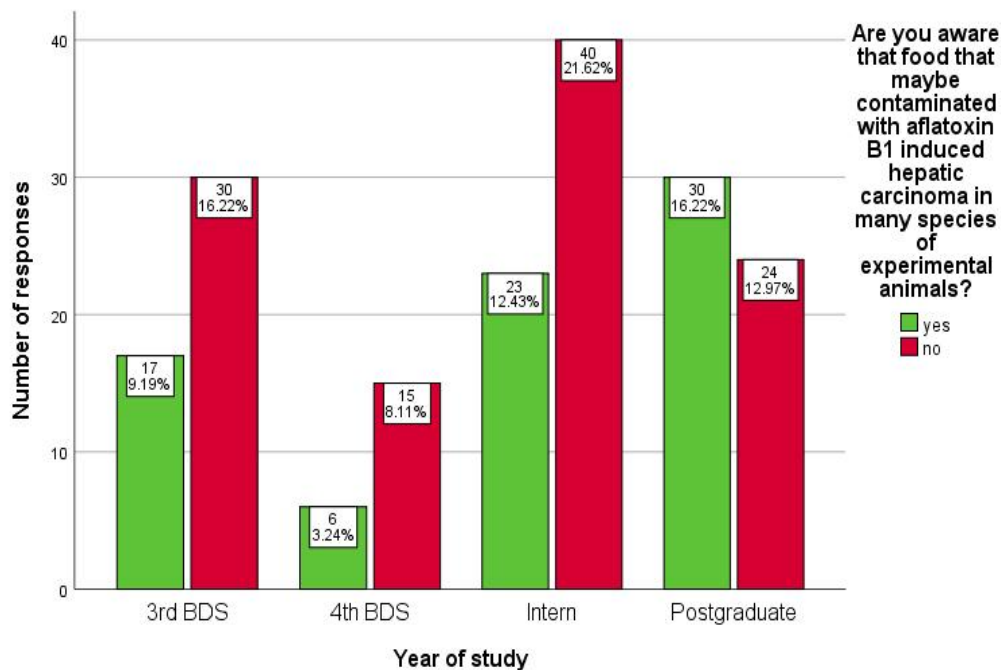
**Fig. 2.** Pie chart represents the responses received from the participants for the question, ‘Are you aware that smoke condensates derived from grilling fish or meat exhibited potent carcinogenic activity?’. About 63.78% of the students answered yes



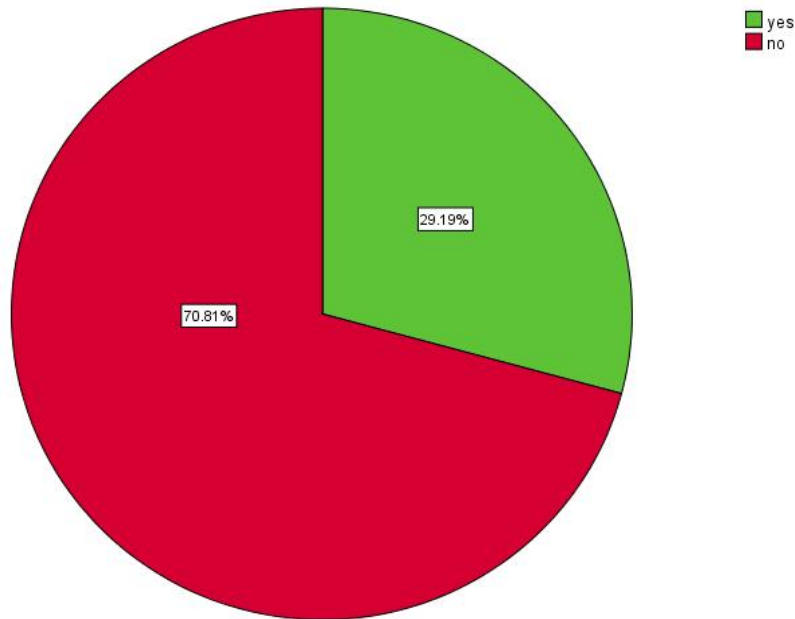
**Fig. 3.** Bar chart representing the association between the year of study and the responses for the question, ‘Are you aware that smoke condensates derived from grilling fish or meat exhibited potent carcinogenic activity?’. The X-axis represents the year of study and Y-axis represents the number of responses. A Chi-square test was done and it was found to be statistically not significant. Pearson Chi-square value = 8.290; p-value = 0.401(>0.05). The majority of postgraduates answered yes, followed by interns



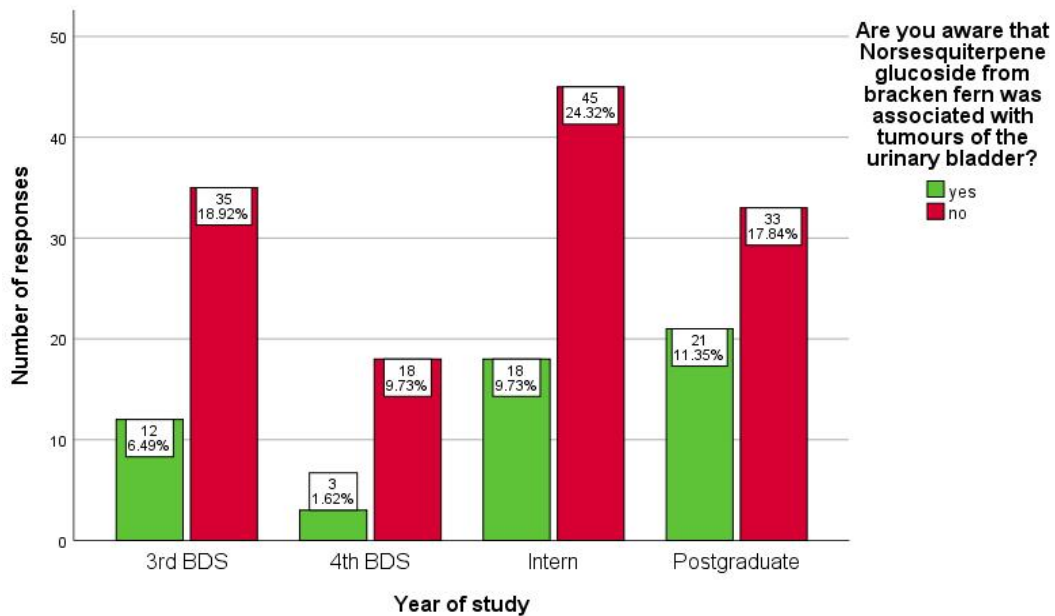
**Fig. 4.** Pie chart represents the responses received from the participants for the question, ‘Are you aware that food that may be contaminated with aflatoxin B1 induced hepatic carcinoma in many species of experimental animals?’. About 41.06% of the students answered yes



**Fig. 5.** Bar chart representing the association between the year of study and the responses for the question, ‘Are you aware that food that may be contaminated with aflatoxin B1 induced hepatic carcinoma in many species of experimental animals?’. The X-axis represents the year of study and Y-axis represents the number of responses. A Chi-square test was done and it was found to be statistically not significant. Pearson Chi-square value = 7.045; p-value = 0.701(>0.05). The majority of postgraduates answered yes, followed by interns



**Fig. 6.** Pie chart represents the responses received from the participants for the question, 'Are you aware that Norsesquiterpene glucoside from bracken fern was associated with tumors of the urinary bladder?'. About 29.19% of the students answered yes



**Fig. 7.** Bar chart representing the association between the year of study and the responses for the question, 'Are you aware that Norsesquiterpene glucoside from bracken fern was associated with tumors of the urinary bladder?'. The X-axis represents the year of study and Y-axis represents the number of responses. A Chi-square test was done and it was found to be statistically not significant. Pearson Chi-square value = 5.031; p-value = 0.170(>0.05). The majority of postgraduates answered yes, followed by interns

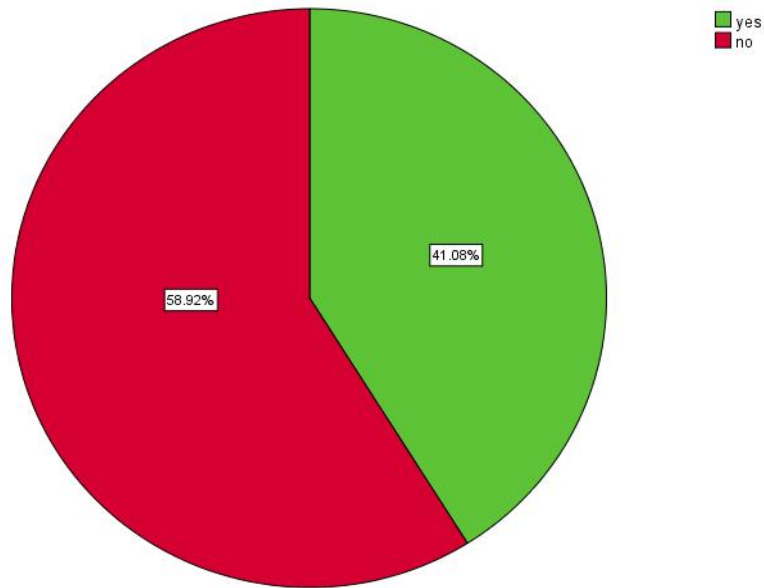


Fig. 8. Pie chart represents the responses received from the participants for the question, 'Are you aware that pyrrolizidine alkaloids present in edible plants have been shown to be carcinogenic in rodents?' About 41.08% of the students answered yes

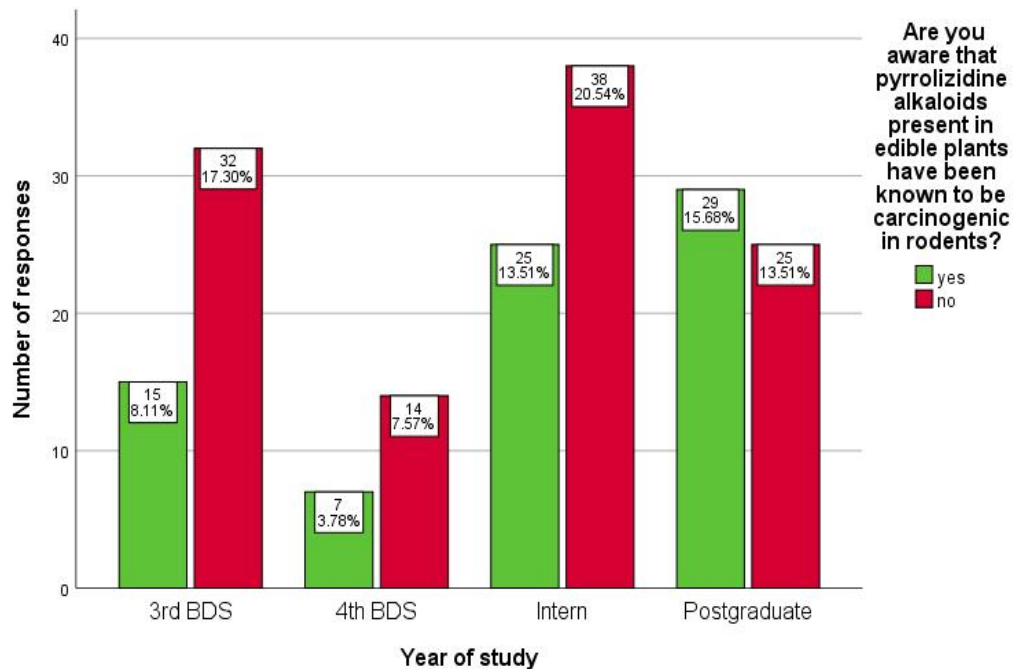
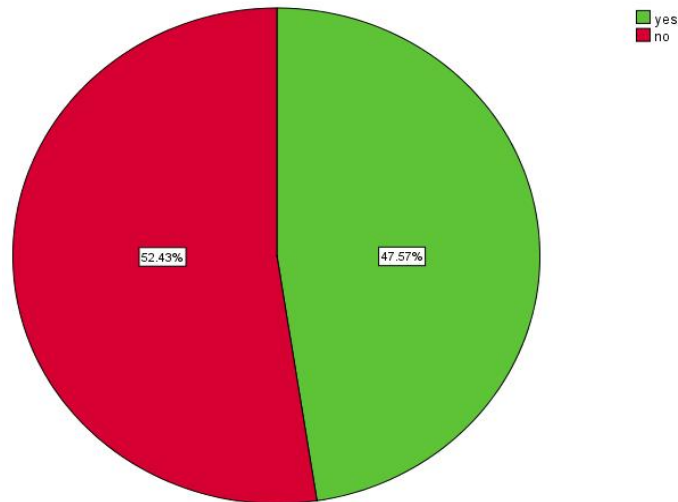
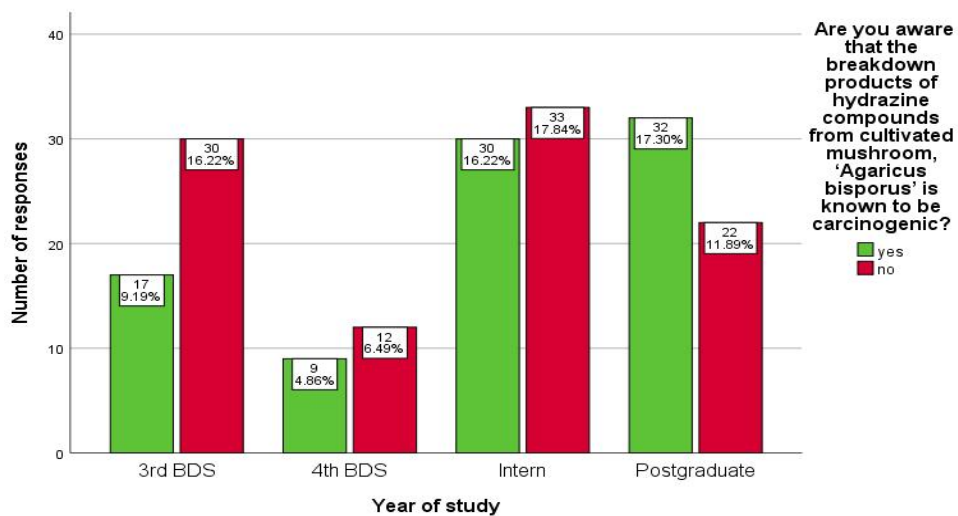


Fig. 9. Bar chart representing the association between the year of study and the responses for the question, 'Are you aware that pyrrolizidine alkaloids present in edible plants have been shown to be carcinogenic in rodents?'. The X-axis represents the year of study and Y-axis represents the number of responses. A Chi-square test was done and it was found to be statistically not significant. Pearson Chi-square value = 5.758; p-value = 0.124(>0.05). The majority of postgraduates answered yes, followed by interns



**Fig. 10.** Pie chart represents the responses received from the participants for the question, 'Are you aware that the breakdown products of hydrazine compounds from cultivated mushrooms, 'Agaricus bisporus' is known to be carcinogenic?'. About 47.57% of the students answered yes



**Fig. 11.** Bar chart representing the association between the year of study and the responses for the question, 'Are you aware that the breakdown products of hydrazine compounds from cultivated mushrooms, 'Agaricus bisporus' is known to be carcinogenic?'. The X-axis represents the year of study and Y-axis represents the number of responses. A Chi-square test was done and it was found to be statistically not significant. Pearson Chi-square value = 5.594; p-value = 0.133(>0.05). The majority of postgraduates answered yes, followed by interns

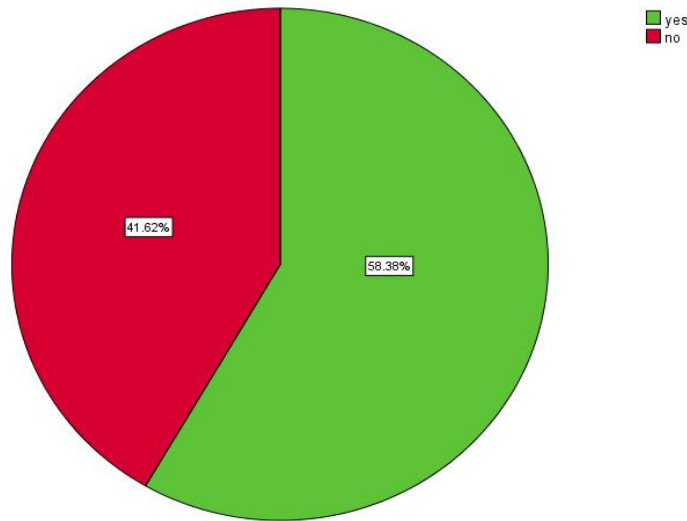
About 56.38% of students were aware that benzoic acid which a widely used food preservative decarboxylates into benzene and is associated with cancer in humans [Fig. 12]. Among them, 24.32% were postgraduates, 17.84% were interns, 5.41% were final year students and 10.81% were third-year students. There was a significant association ( $p=0.000$ )

between the year of study and the response to the question, 'Are you aware that benzoic acid which a widely used food preservative decarboxylates into benzene and is associated with cancer is humans?' [Fig. 13]. About 80% of students were aware that ethanol present in alcoholic beverages poses the highest level of evidence among all carcinogenic food agents

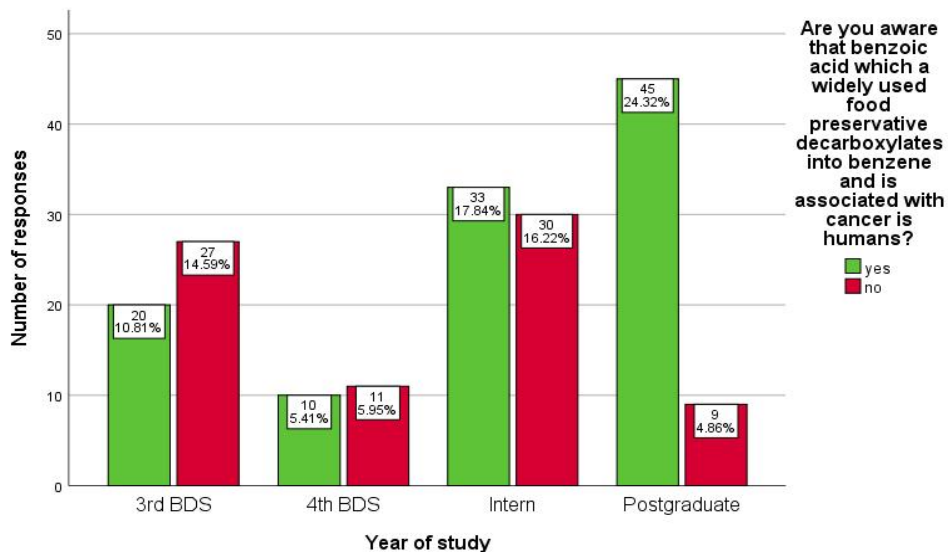


[Fig. 14]. Among them, 26.49% were postgraduates, 28.11% were interns, 7.57% were final year students and 17.84% were third-year students. There was no significant association ( $p=0.261$ ) between the year of study and the response to the question, 'Are you aware that

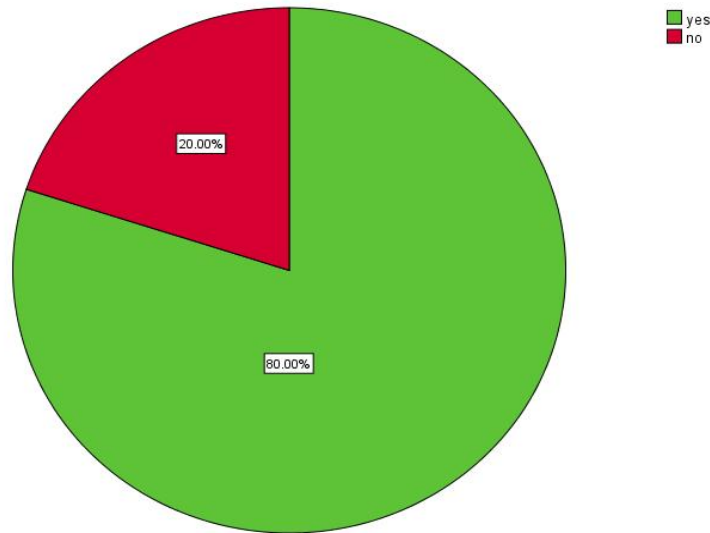
ethanol present in alcoholic beverages poses the highest level of evidence among all carcinogenic food agents?' [Fig. 15]. About 67.03% of students were aware that alcohol can impact the levels of hormones that are linked to breast cancer



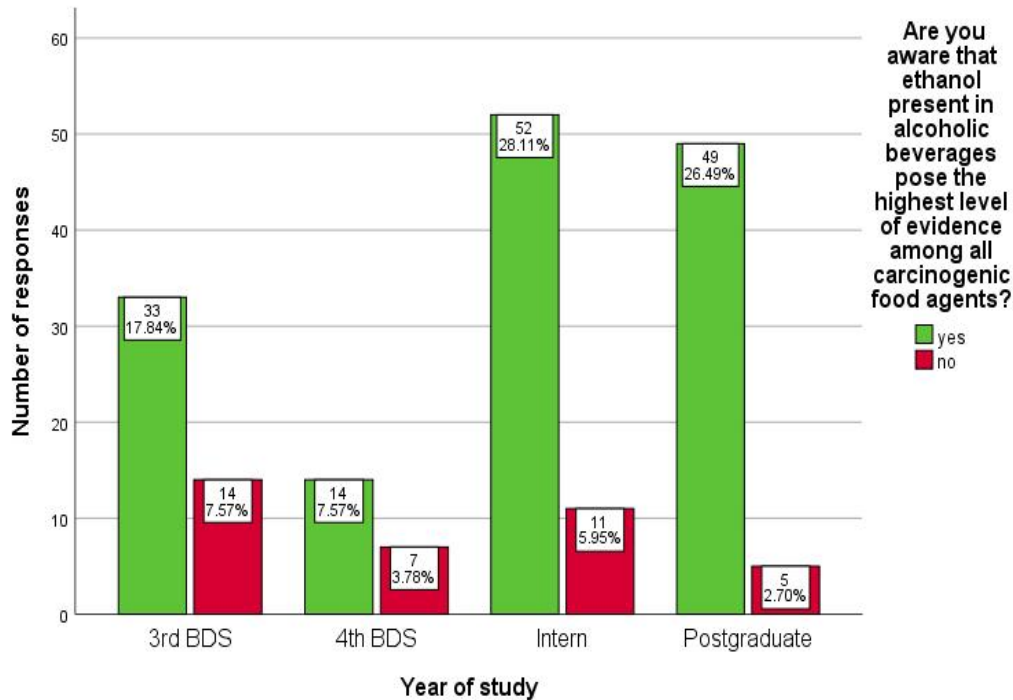
**Fig. 12.** Pie chart represents the responses received from the participants for the question, 'Are you aware that benzoic acid which a widely used food preservative decarboxylates into benzene and is associated with cancer is humans?'. About 58.38% of the students answered yes



**Fig. 13.** Bar chart representing the association between the year of study and the responses for the question, 'Are you aware that benzoic acid which a widely used food preservative decarboxylates into benzene and is associated with cancer in humans?'. The X-axis represents the year of study and Y-axis represents the number of responses. A Chi-square test was done and it was found to be statistically significant. Pearson Chi-square value = 20.617;  $p$ -value = 0.000 ( $<0.05$ ). The majority of postgraduates answered yes, followed by interns



**Fig. 14.** Pie chart represents the responses received from the participants for the question, 'Are you aware that ethanol present in alcoholic beverages poses the highest level of evidence among all carcinogenic food agents?'. About 80% of the students answered yes



**Fig. 15.** Bar chart representing the association between the year of study and the responses for the question, 'Are you aware that ethanol present in alcoholic beverages poses the highest level of evidence among all carcinogenic food agents?'. The X-axis represents the year of study and Y-axis represents the number of responses. A Chi-square test was done and it was found to be statistically not significant. Pearson Chi-square value = 9.295; p-value = 0.261(>0.05). The majority of postgraduates answered yes, followed by interns

#### 4. DISCUSSION

This study was done to evaluate the level of awareness of food carcinogens among dental students, including both undergraduates and postgraduates. Considering the responses, it can be interpreted that the knowledge regarding food carcinogens is above average among dental students. Also, postgraduate students were more knowledgeable than undergraduate students. Interns showed more awareness than a third-year or final year undergraduate students. Students were also more aware of the carcinogenic properties associated with the usage of alcohol.

The potential role in the carcinogenesis of food additives and contaminants presents a complex problem in terms of assessing the risk to the general public [25]. It is therefore of utmost importance to increase the general awareness among young people about the carcinogenic effects of various food items [26]. In our study, about 63.78% were aware that smoke condensates derived from grilling fish or meat exhibited potent carcinogenic activity. The series of mutagenic and carcinogenic HCAs were discovered due to curiosity about daily life conditions [27]. Smoke condensates derived from grilling fish (sardine, horse mackerel, and herring) and meat (beef) thereby exhibited potent mutagenic activity with S9 mix metabolic activation, especially to a frameshift type mutagen detector, *S.typhimurium* TA98. The mutagenic principle was found to be present in a basic fraction and different from polycyclic aromatic hydrocarbons (PAHs) [28]. Foods may be contaminated with toxins of the mold *Aspergillus flavus*. A well known typical toxin is aflatoxin B1 (AFB1) which induces hepatic carcinomas in many species of experimental animals including rats, monkeys, and fish. AFB1 is metabolically activated to its 8,9-epoxide by cytochrome P450s and modifies DNA with the formation of 8,9-dihydro-8-(N7-guanyl)-9-hydroxy aflatoxin B1 adducts [29]. Only about 41.08% of students were aware of this.

Bracken fern was called to the attention of scientists by the finding that cows pastured in fields where bracken fern was growing, developed hematuria with tumors of the urinary bladder. Feeding rats with bracken fern yielded carcinomas in the intestine and mammary glands, in addition to in the urinary bladder [30]. Only 29.19% of students were aware of this. About 41.08% of students were aware that

pyrrolizidine alkaloids present in various edible plants have been shown to be mutagenic in *Salmonella* strains and carcinogenic in rodents. Petasitenine and senkirkine are responsible for the carcinogenicity of two kinds of coltsfoot, *P.japonicus* Maxim and *T.farfara* L., respectively, inducing liver tumors in rats [31]. The commonly eaten cultivated mushroom, *Agaricus bisporus*, contains a hydrazine compound, agaritine ( $\beta$ -N-[ $\gamma$ -L(+)-glutamyl]-4-hydroxymethyl phenyl hydrazine), and its decomposition products. Three breakdown products of agaritine are known to be carcinogenic in mice. In addition, uncooked cultivated mushrooms themselves are carcinogenic in mice, inducing tumors in the bone, forestomach, liver, and lung. Agaritine is also present in the Japanese forest mushroom, *Cortinellus shiitake* [32]. About 47.57% of students were aware of this. Concerns about benzene contamination of food arose in the early 1990s since it was a highly evident carcinogenic agent. Several sources can contribute to the occurrence of benzene in foods. Benzoic acid, a widely used food preservative, may decarboxylate to benzene in the presence of ascorbic acid and about 56.38% of students knew this. Benzene can also be introduced into foods through leaching from various packaging materials or storage environments, from contamination of water supplies, or it may be formed during irradiation processes. Another source of benzene in soft drinks and beer was the use of contaminated carbon dioxide [33].

The majority of dental students were aware of the fact that alcohol and processed meat are classified as a 'Group 1 carcinogen' which means that the evidence that they can be linked to cancer is extremely strong, particularly cancer of the mouth, throat, esophagus, breast, liver, stomach and bowel. It's estimated that around 3,200 cancer cases in Australia are attributed to alcohol consumption each year [34]. The reason why alcohol is linked to cancer is that alcohol can damage the lining of the mouth and throat, causing cancer in these parts of the body. Alcohol can also impact the levels of hormones that are linked to breast cancer [35]. The reason why red meat and processed meats are carcinogenic is due to the chemicals they contain. When a chemical in processed meat called haem is broken down in the gut, N-nitroso chemicals are formed and these have been found to damage the cells that line the bowel, which can lead to bowel cancer [36]. The nitrite preservatives used to preserve processed meat

also produce these N-nitroso chemicals and can lead to bowel cancer. The risk of developing cancer based on ingesting foods classified as carcinogenic also depends on other factors including how the individual is exposed to the product, how much they eat, and for how long they have been eating it [37].

Very few students were aware that salted fish, beverages at high temperatures, and coffee were associated with carcinogenic agents. Salted fish is produced in several parts of Asia using a method that appears to result in the production of carcinogenic byproducts. Several potential carcinogens have been identified including N-nitrosodimethylamine, other N-nitroso compounds. Ecologic and case-control studies have demonstrated an increased risk of nasopharyngeal carcinoma in subjects consuming larger amounts of Chinese-style salted fish [38]. The interaction between cancer risk and the quantity consumed and the temperature of consumption of beverages like tea/maté suggests that thermal injury and not the maté are responsible for some or all of the increased risk of cancer. Subjects consume large quantities of tea, some preferring very high temperatures, sometimes in excess of 65°C were at an increased risk of esophageal cancer [39]. Coffee is grown and consumed the world over and was listed in 1991 by IARC as possibly carcinogenic to humans. Some evidence had linked coffee to an increased risk of bladder cancer [40]. Above half of the study, the population was aware of the association between pickled vegetables, acrylamide in food like fried potatoes, and cancer risk. Pickled vegetables have been studied for their association with cancer mainly in Asia and especially in the People's Republic of China. The pickling process is different from that used in many parts of the world and uses no salt or vinegar. Instead, it relies on natural fermentation and can lead to contamination with mold. Epidemiologic studies have suggested an increased risk of esophageal cancer in pickled vegetable consumers [41]. Acrylamide is created in the process of high-temperature cooking of certain foods such as potatoes and cereals. Acrylamide was previously listed by IARC as probably carcinogenic to humans [42].

According to this study, postgraduates had more awareness followed by interns. Limitations of this study include dishonest answers in the questionnaire by respondents and usage of a single online survey platform in a single

university setting. Future studies should aim at conducting surveys using multiple online survey platforms to include more participants in different university settings.

## 5. CONCLUSION

This study shows that postgraduates have the most awareness of food carcinogens among all dental students. Numerous food contaminant concerns exist and several food contaminants have been confirmed as carcinogenic to humans. Educational conferences and CDE's are essential for dental students to improve their knowledge regarding various food carcinogens. Once there is sufficient awareness among people, the reduction of exposure can be initiated through government regulation, food producer initiatives, and individual dietary changes.

## CONSENT

As per international standard or university standard, respondents' written consent has been collected and preserved by the author(s).

## ETHICAL APPROVAL

Ethical approval was obtained from the institution's ethical committee.

## ACKNOWLEDGEMENTS

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## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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