



Knowledge and Awareness about Transdermal Drug Patches among Dental Students

A. Trishala¹, Dhanraj Ganapathy^{2*} and M. P. Santhosh Kumar³

¹*Saveetha Institute of Medical and Technical Sciences, Saveetha Dental College and Hospitals, Saveetha University, Chennai, India.*

²*Department of Prosthodontics, Saveetha Dental College and Hospitals, Saveetha Institute of Medical and Technical Sciences, Saveetha University, Chennai, India.*

³*Department of Oral and Maxillofacial Surgery, 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

Transdermal delivery is a non-invasive route of drug administration through the skin surface that can deliver the drug at a predetermined rate across the dermis to achieve a local or systemic effect. It is potentially used as an alternative to oral routes of drugs and hypodermic injections. The aim of this study was to assess the knowledge and awareness of transdermal drug patches among dental students. A structured self-assessed online questionnaire having 15 questions on transdermal drug patches 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, 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 transdermal drug patches is above average among dental students. Also, postgraduate students were more knowledgeable than undergraduate students. Interns showed more awareness

*Corresponding author: E-mail: ghanraj@saveetha.com;

than a 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 transdermal drug patches and their adverse reactions.

Keywords: Awareness; dental students; skin permeation; transdermal drug patches.

1. INTRODUCTION

Transdermal drug delivery system, now often known as patches, is a non-invasive way of delivering medications across the dermis or skin surface. It is potentially used as an alternative to administering oral routes of drugs and hypodermic injections [1]. This drug delivery system can deliver an analgesic at a predetermined rate across the skin to receive a systemic or a local effect [2]. Transdermal patches are not a new concept. It was first used for systemic delivery, a three-day patch, scopolamine to treat motion sickness, approved in the United States in 1979. A decade later, the success of nicotine patches brought in more awareness and usage of transdermal drugs [3].

Today, over 35 drugs are used as transdermal patches, with at least 13 approved molecules [4]. The therapeutic horizon of transdermal patches is now expanding to include hormone replacement, analgesic, relief of chest pain by heart disorders, smoking cessation, and neurologic disorders. Transdermal patches have a number of advantages over oral and hypodermic injections [5]. It provides better biocompatibility in the first pass hepatic metabolism. Increased flexibility in drug administration by patch removal, painless application, and prolonged application for 1 week are other advantages. There is improved patient compliance as the treatment is non-invasive, simple, and convenient, and there is greater flexibility in the termination of drugs by the removal of patches [6]. Controlled delivery of drugs through the skin can provide less fluctuation and reduce the drug spike concentration observed after the orally delivered drugs [7].

However, this drug delivery system has not completely achieved its potential due to a few limitations. Local irritation and sensitization of the skin may limit the number of drugs [8]. Successful transdermal drugs have molecular masses that are only up to a few hundred Daltons, thereby limiting the dosage of the drug too. Difficulties in delivering hydrophilic drugs, the expense of medication, and delayed

absorption are other disadvantages [9]. In the case of young infants, it can be difficult to ensure long-lasting and adequate adhesion. They are more preferred for the elderly where skin irritation can be less expected, and the reliability is increased [10].

Transdermal drugs will continue to gain popularity along with further improvements to improve safety and efficacy. A further major step forward will be the production of patches delivering peptide and even protein substances including insulin, growth hormone, and vaccines [11]. Transdermal patches are now used in pain management for both acute and chronic pain. They are available in various forms which include non-steroidal antiinflammatory drug patches (NSAID), opioid patches, local anesthetic patches, capsaicin, and nitroglycerine. They are commonly used in pediatric practice. Considering the importance and uses of transdermal drug patches, this study evaluates the level of awareness among dental students [12]. Dentistry has several applications where trans dermal patches can be used for many therapeutic applications. Hence, dental students should have adequate knowledge and awareness of trans dermal patches to enhance the quality of treatment.

Previously our department has published extensive research on various aspects of prosthetic dentistry [13–23], this vast research experience has inspired us to research the knowledge and awareness about transdermal drug patches 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 transdermal drug patches was prepared with the aim to assess the awareness among 200 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.

3. RESULTS

The study was conducted among 200 dental students. Out of 200, 20.5% were third-year undergraduate students, 11.5% were final year undergraduate students, 38.5% were interns and 39.5% were postgraduates [Fig. 1]. About 76% of students were aware that transdermal drug patches are used as an alternative to administering oral drugs and hypodermic injections [Fig. 2]. Among them, 29.5% were postgraduates, 27% were interns, 8% were final year students and 11.5% were third-year students. There was a significant association ($p = 0.001$) between the year of study and the response for the question 'Are you aware that transdermal drug patches are used as an alternative to administering oral drugs and hypodermic injections?' [Fig. 3]. About 80% of students were aware that transdermal drug patches have increased bioavailability [Fig. 4]. Among them, 31% were postgraduates, 27.5% were interns, 8.5% were final year students and 13% were third-year students. There was a significant ($p = 0.003$) between the year of study and the response for the question 'Are you aware that transdermal drug patches have increased bioavailability?' [Fig. 5]. About 41.5% knew that there are three generations of transdermal drug patches [Fig. 6]. Among them, 19% were postgraduates, 16% were interns, 4% were final year students and 2.5% were third-year students. There was a significant association ($p = 0.009$) between the year of study and the response for the question 'Transdermal drug patches are categorized into how many generations?' [Fig. 7]. About 29% of students knew that the first generation transdermal drug patches are limited up to the stratum corneum, the outermost layer of skin [Fig. 8]. Among them, 12.5% were postgraduates, 7% were interns,

3.5% were final year students and 6% were third-year students. There was no significant association ($p = 0.103$) between the year of study and the response to the question 'First-generation transdermal drug patches are limited up to which layer of skin?' [Fig. 9]. About 48.5% of students were aware that the second generation transdermal patches use modifications such as chemical enhancers, iontophoresis, and non-cavitation ultrasound to increase the delivery [Fig. 10]. Among them, 19.5% were postgraduates, 15% were interns, 5% were final year students and 9% were third-year students. There was no significant association ($p = 0.131$) between the year of study and the response to the question, 'Are you aware that the second generation transdermal patches use modifications such as chemical enhancers, iontophoresis, and non-cavitation ultrasound to increase the delivery?' [Fig. 11].

Only 29% knew that chemical enhancers modify the rate of delivery of second-generation transdermal drug patches by inserting amphiphilic molecules to help in better permeation [Fig. 12]. Among them, 11.5% were postgraduate students, 8.5% were interns, 4% were final year students and 5% were third-year students. There was no significant association ($p = 0.529$) between the year of study and the response to the question, 'How do chemical enhancers modify the rate of delivery of second-generation transdermal drug patches?' [Fig. 13]. About 54% were aware that non-cavitated ultrasound used in second-generation transdermal drug patches were limited due to its associated tissue healing [Fig. 14]. Among them, 23% were postgraduates, 17% were interns, 5.5% were final years and 8.5% 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 non-cavitated ultrasound used in second-generation transdermal drug patches is limited due to its associated tissue healing?' [Fig. 15]. Only 25% of students knew that microdermabrasion, microneedles, and thermal ablation are used for delivery of 3rd generation of transdermal drug patches [Fig. 16]. Among them, 13.5% were postgraduates, 11% were interns, 3.5% were final year students and 7.5% were third-year students. There was no significant association ($p = 0.662$) between the year of study and the response for the question 'Microdermabrasion, microneedles and thermal ablation are used for delivery of which generation of transdermal drug patches?' [Fig. 17]. About 56%

were aware that the controlled delivery of drugs through the skin can reduce the drug spike concentration [Fig. 18]. Among them, 23.5% were postgraduates, 18% were interns, 6.5% were final year students and 8% 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 controlled delivery of drugs through the skin can reduce the drug spike concentration?' [Fig. 19]. Only 36.5% of students knew that 1% of diclofenac epolamine is the most common NSAID patch used [Fig. 20]. Among them, 16.5% were postgraduates, 11% were interns, 3.5% were final year students and 5.5% were third-year students. There was no significant association ($p=0.291$) between the year of study and the response for the question, 'Which is the most common NSAID patch?' [Fig. 21].

About 43% of students knew that it takes < 20 minutes for local anesthetic transdermal patches to provide anesthesia [Fig. 22]. Among them, 18% were postgraduates, 14% were interns, 3.5% were final year students and 7.5% were third-year students. There was a significant association ($p=0.007$) between the year of study and the question, 'How long does it take for local anesthetic transdermal drug patches to provide anesthesia?' [Fig. 23]. About 55% of students were aware that capsaicin dermal patches should not be used on open wounds [Fig. 24]. Among them 20.5% were postgraduate students, 19.5% were interns, 6% were final year students

and 9% were third-year students. There was no significant association ($p=0.161$) between the year of study and the response to the question, 'Are you aware that capsaicin dermal patches should not be used on open wounds?' [Fig. 25]. Only 34% of students knew that the ideal size of a transdermal drug patch is < 40 cm² [Fig. 26]. Among them, 13% were postgraduates, 13% were interns, 4% were final year students and 4% were third-year students. There was no significant association ($p=0.290$) between the year of study and the response to the question 'What is the ideal size of a transdermal drug patch?' [Fig. 27]. About 55% of students were aware that scopolamine was the first transdermal drug patch to be used against motion sickness [Fig. 28]. Among them, 22.5% were postgraduates, 17.5% were interns, 6.5% were final year students and 8.5% were third-year students. There was a significant association ($p=0.001$) between the year of study and the response to the question, 'Are you aware that scopolamine was the first transdermal drug patch to be used against motion sickness?' [Fig. 29]. About 65% were aware that contact dermatitis is the most common side effect of transdermal drug patches [Fig. 30]. Among them, 27.5% were postgraduates, 21% were interns, 6.5% were final year students and 10% were third-year students. There was no significant association ($p=0.491$) between the year of study and the response for the question 'Are you aware that the most common side effect of transdermal drug patches is contact dermatitis?' [Fig. 31].

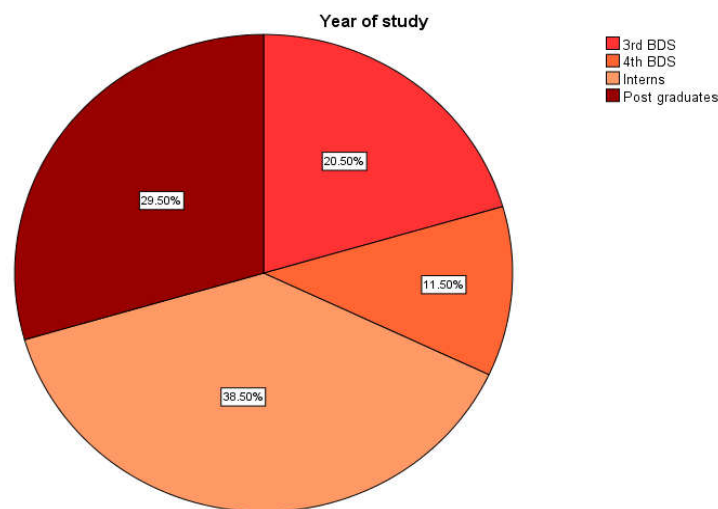


Fig. 1. Pie chart represents the year of study of dental students included in this study. Majority of the study population were interns (38.5%), followed by postgraduates (29.5%), third year students(20.5%) and final year students (11.5%)

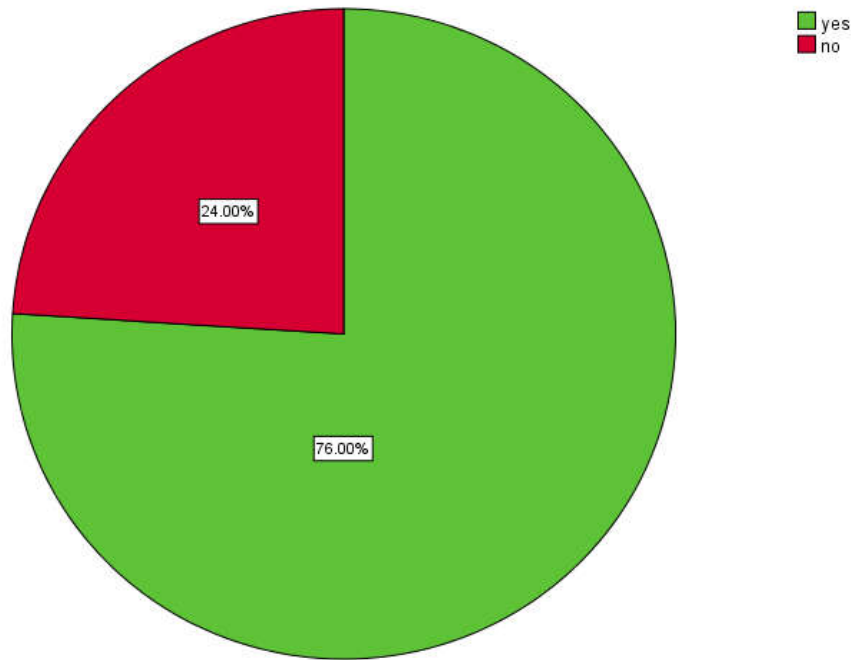


Fig. 2. Pie chart represents the responses received from the participants for the question, ‘Are you aware that transdermal drug patches are used as an alternative to administer oral drugs and hypodermic injections?’ About 76% of the students answered yes

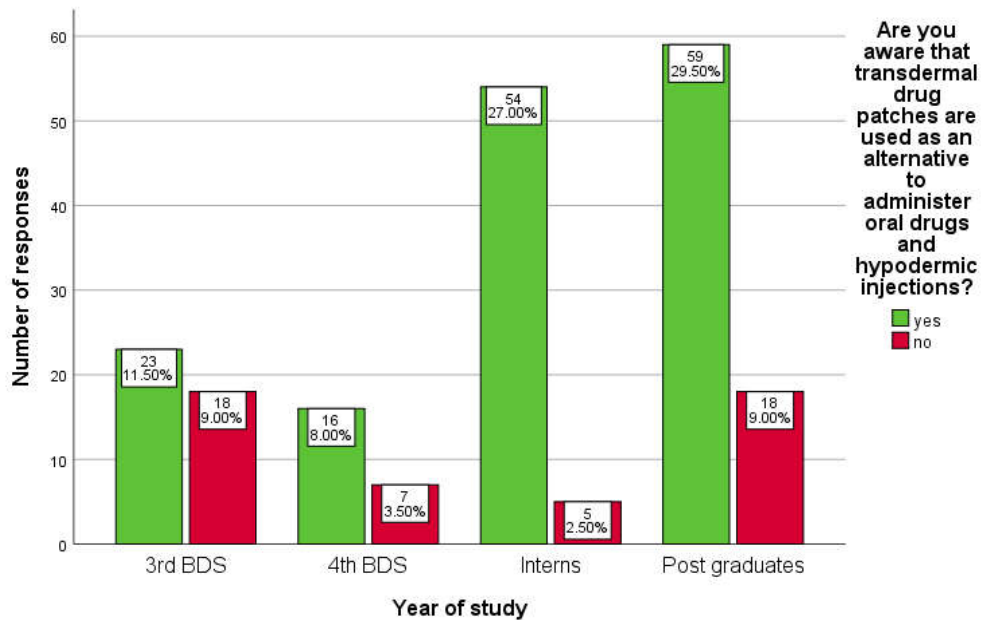


Fig. 3. Bar chart representing the association between the year of study and the responses for the question, ‘Are you aware that transdermal drug patches are used as an alternative to administer oral drugs and hypodermic injections?’. X axis represents the year of study and Y axis represents the number of responses. Chi square test was done and it was found to be statistically significant. Pearson Chi square value = 17.239; p-value = 0.001 (<0.05). Majority of postgraduates answered yes, followed by interns

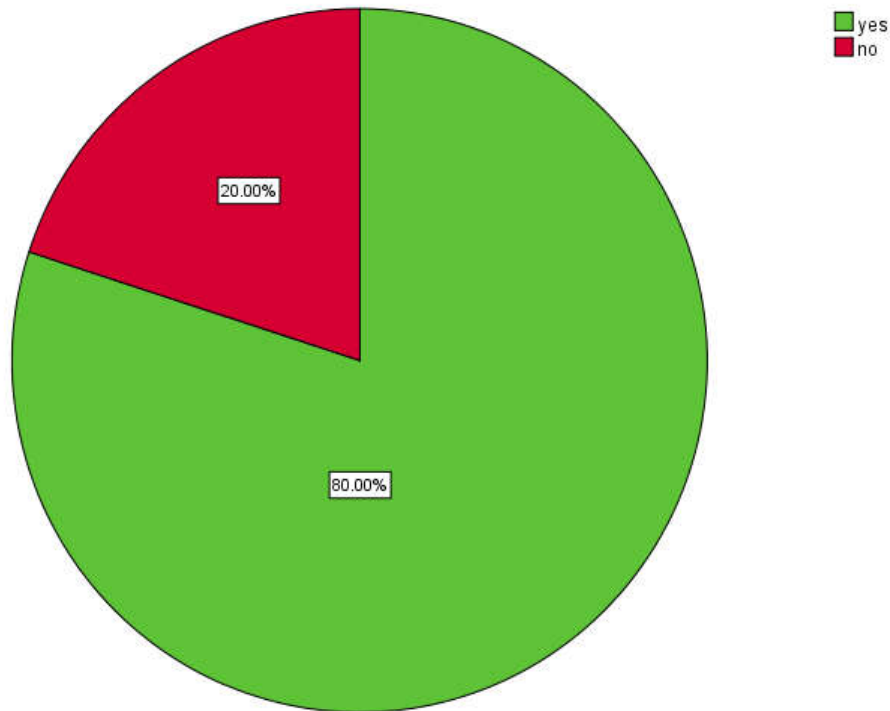


Fig. 4. Pie chart represents the responses received from the participants for the question, 'Are you aware that transdermal drug patches have increased bioavailability?'. About 80% of the students answered yes

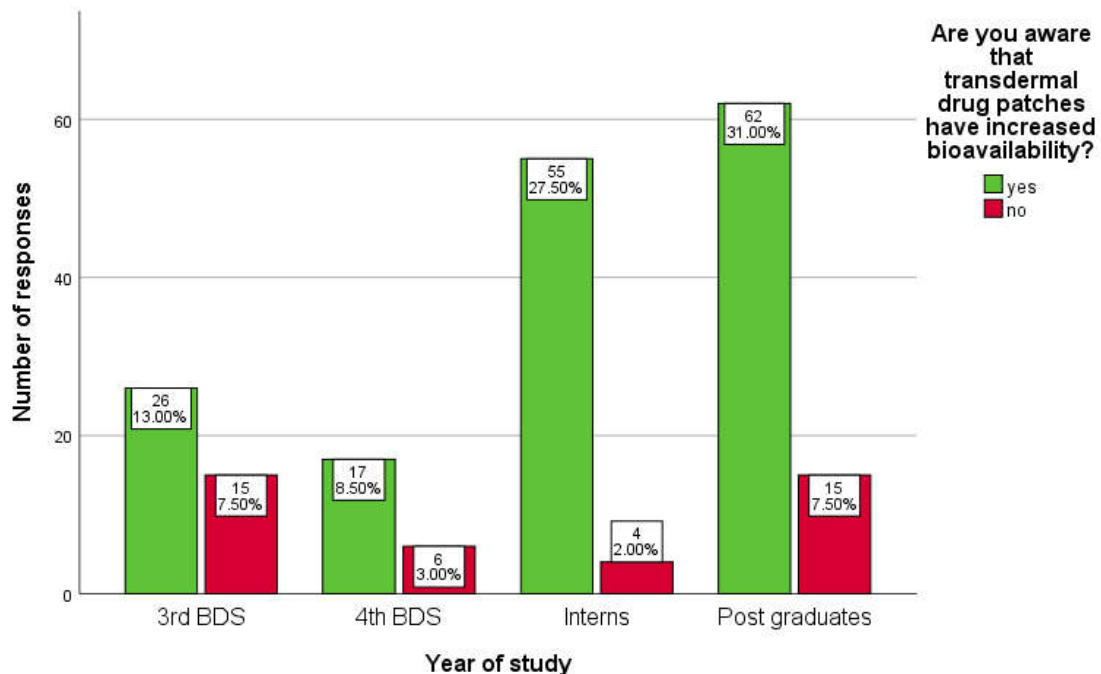


Fig. 5. Bar chart representing the association between the year of study and the responses for the question, 'Are you aware that transdermal drug patches have increased bioavailability?'. X axis represents the year of study and Y axis represents the number of responses. Chi square test was done and it was found to be statistically significant. Pearson Chi square value = 14.039; p-value = 0.003(<0.05). Majority of postgraduates answered yes, followed by interns

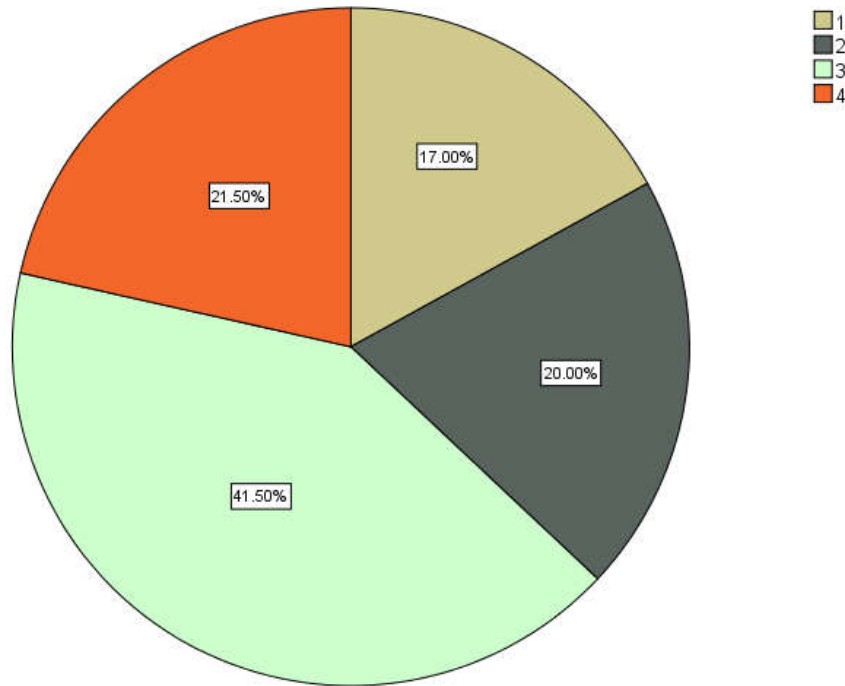


Fig. 6. Pie chart represents the responses received from the participants for the question, 'Transdermal drug patches are categorised into how many generations?'. About 41.5% of the participants answered 3, which is the correct answer

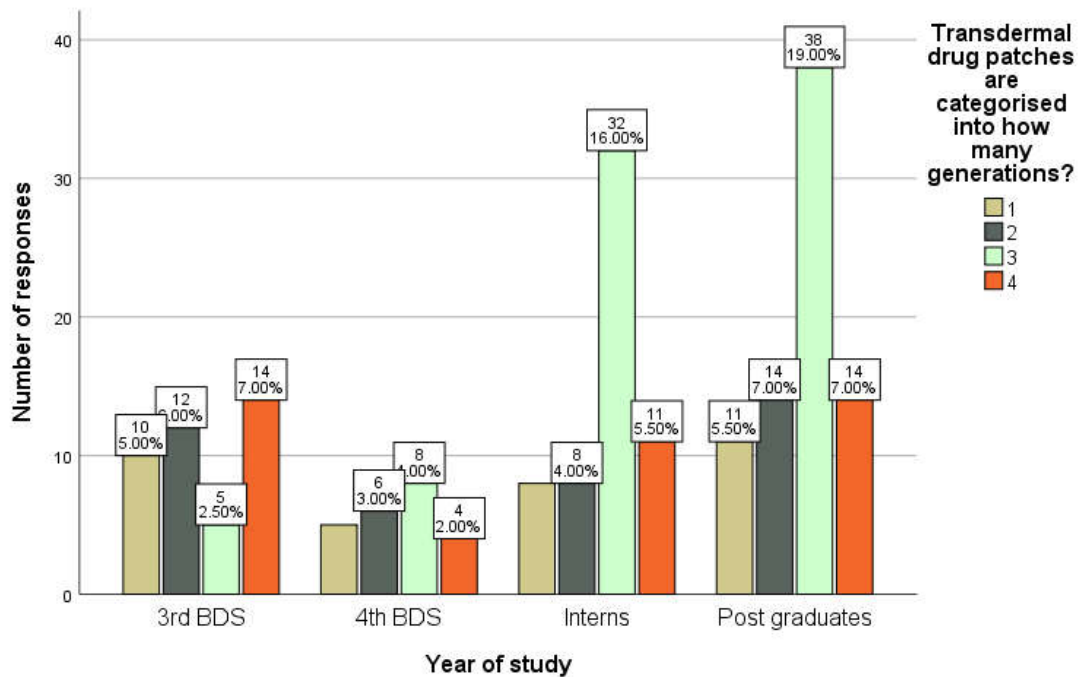


Fig. 7. Bar chart representing the association between the year of study and the responses for the question, 'Transdermal drug patches are categorised into how many generations?'. X axis represents the year of study and Y axis represents the number of responses. Chi square test was done and it was found to be statistically significant. Pearson Chi square value = 21.937; p-value = 0.009(<0.05). Majority of postgraduates knew the correct answer which is 3

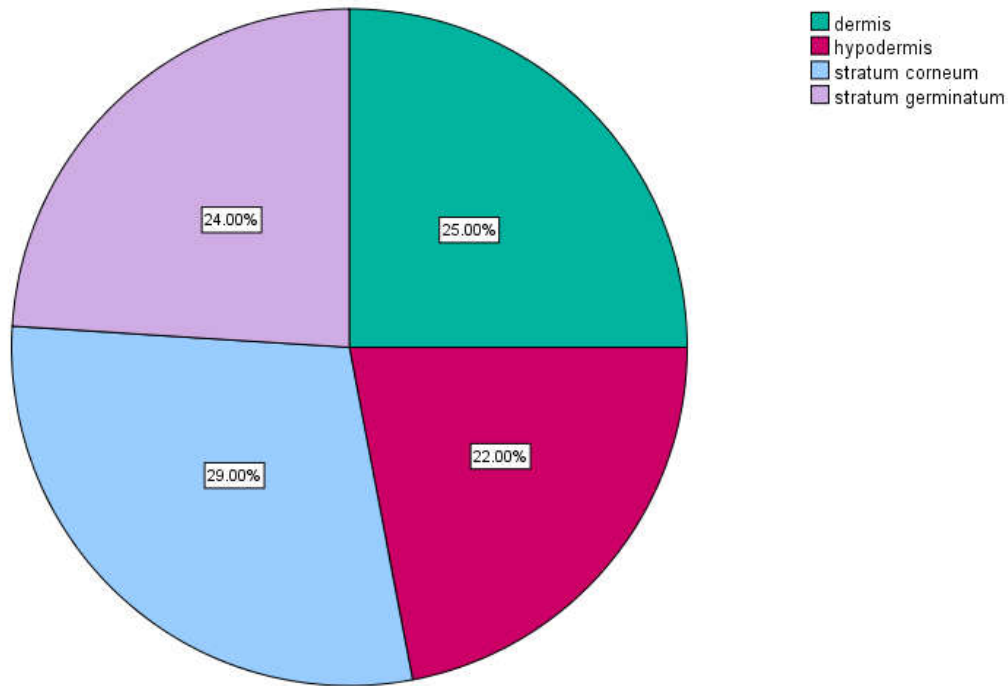


Fig. 8. Pie chart represents the responses received from the participants for the question, 'First generation transdermal drug patches are limited upto which layer of skin?' Only 29% of the participants answered stratum corneum, which is the correct answer

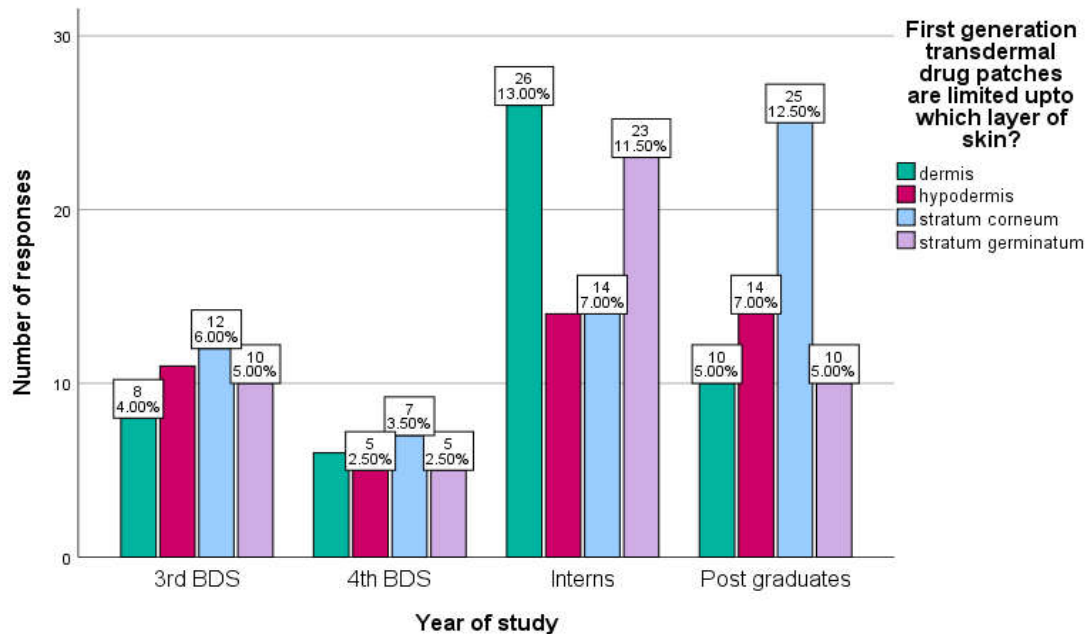


Fig. 9. Bar chart representing the association between the year of study and the responses for the question, 'First generation transdermal drug patches are limited upto which layer of skin?'. X axis represents the year of study and Y axis represents the number of responses. Chi square test was done and it was found to be statistically not significant. Pearson Chi square value = 14.569; p-value = 0.103(>0.05). Majority of postgraduates knew the correct answer which is stratum corneum

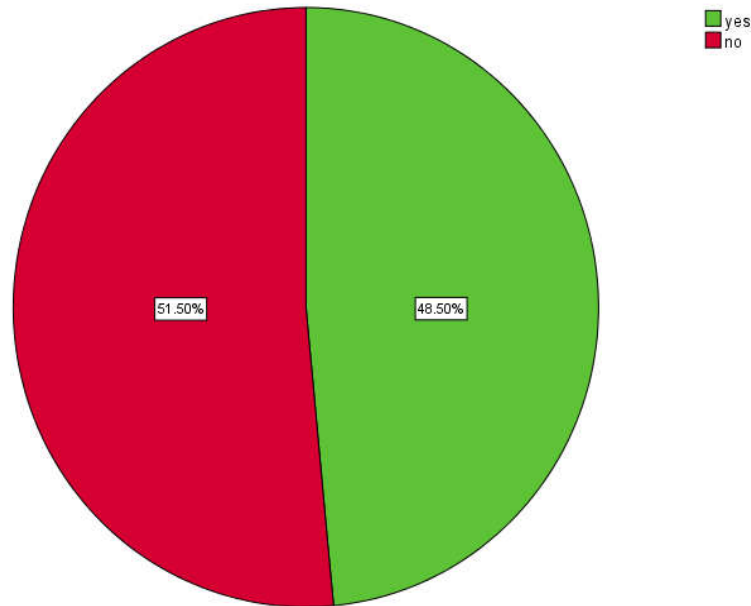


Fig. 10. Pie chart represents the responses received from the participants for the question, 'Are you aware that the second generation transdermal patches use modifications such as chemical enhancers, iontophoresis and non-cavitation ultrasound to increase the delivery?'. About 48.5% of the students answered yes

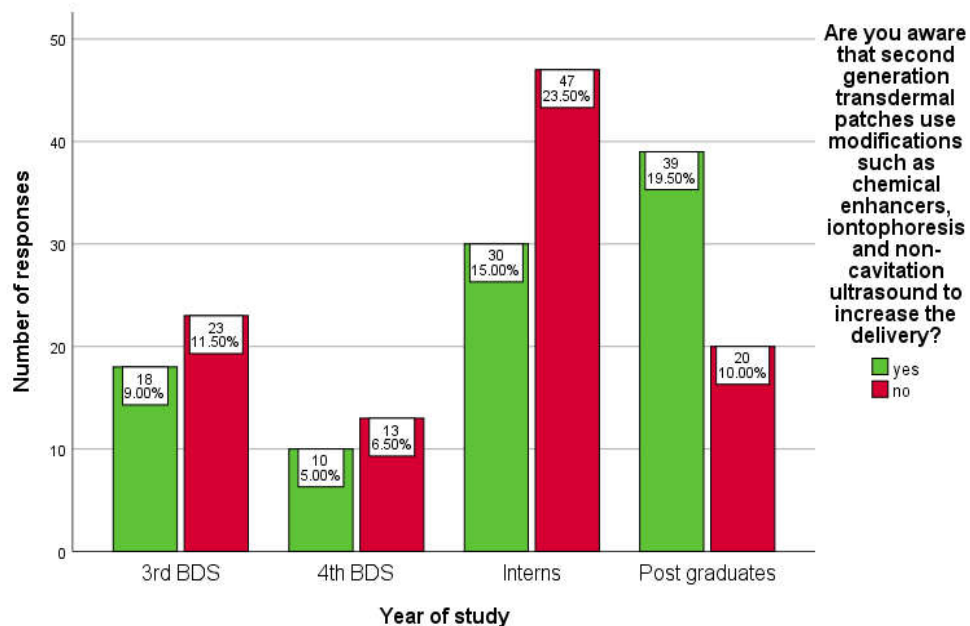


Fig. 11. Bar chart representing the association between the year of study and the responses for the question, 'Are you aware that the second generation transdermal patches use modifications such as chemical enhancers, iontophoresis and non-cavitation ultrasound to increase the delivery?'. X axis represents the year of study and Y axis represents the number of responses. Chi square test was done and it was found to be statistically not significant. Pearson Chi square value = 10.703; p-value = 0.131(>0.05). Majority of postgraduates answered yes, followed by interns

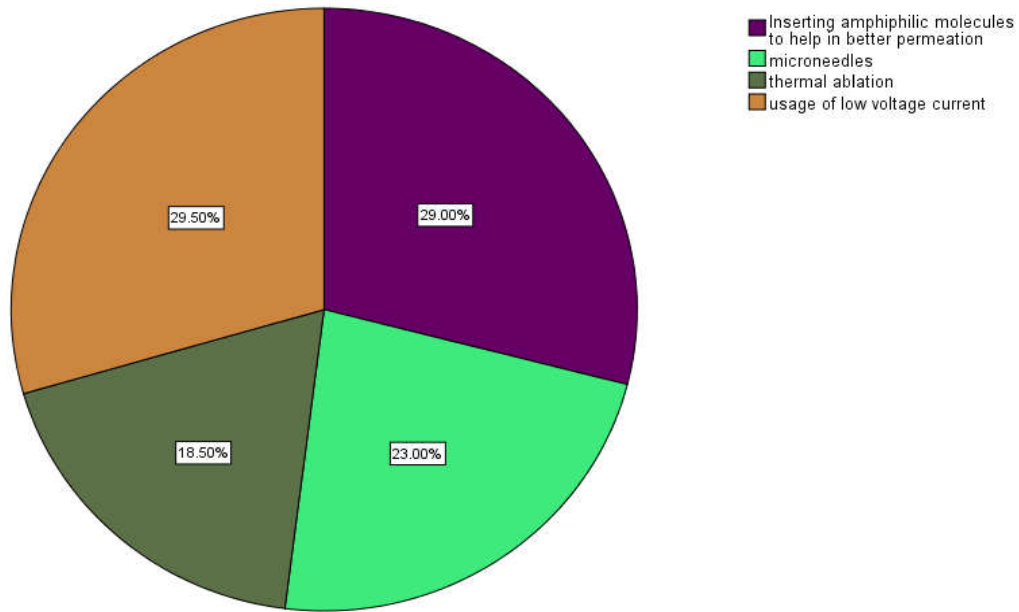


Fig. 12. Pie chart represents the responses received from the participants for the question, 'How do chemical enhancers modify the rate of delivery of second generation transdermal drug patches?' Only 29% of the participants answered inserting amphiphilic molecules to help in better permeation, which is the correct answer

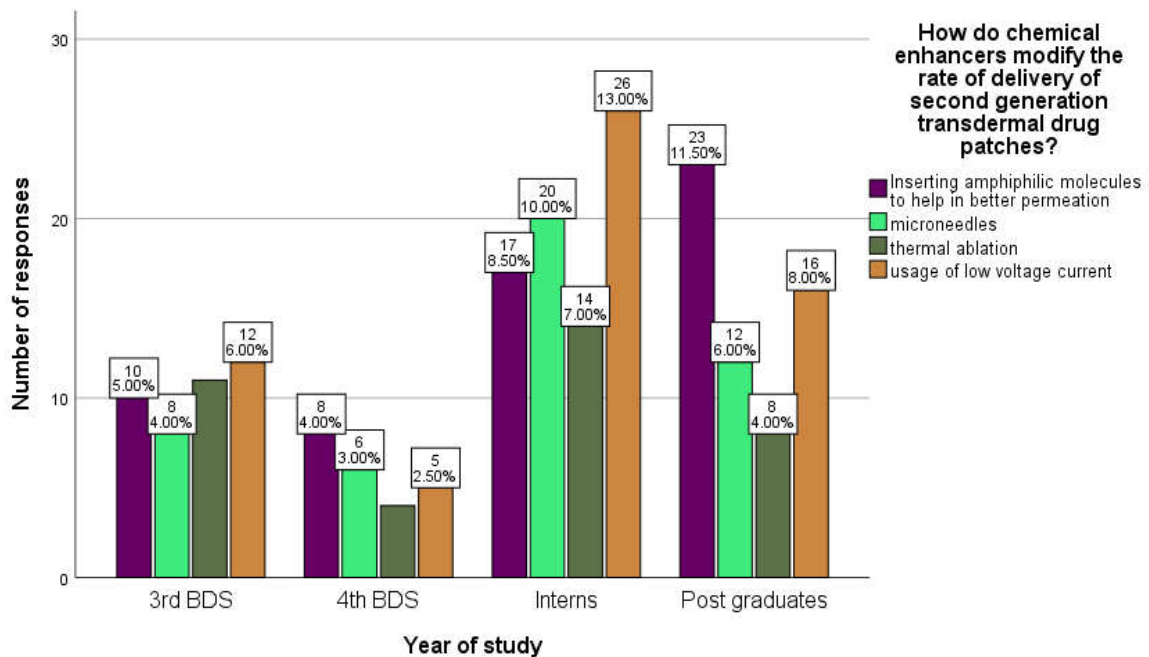


Fig. 13. Bar chart representing the association between the year of study and the responses for the question, 'How do chemical enhancers modify the rate of delivery of second generation transdermal drug patches?'. X axis represents the year of study and Y axis represents the number of responses. Chi square test was done and it was found to be statistically not significant. Pearson Chi square value = 8.050; p-value = 0.529(>0.05). Majority of postgraduates knew the correct answer which is inserting amphiphilic molecules to help in better permeation

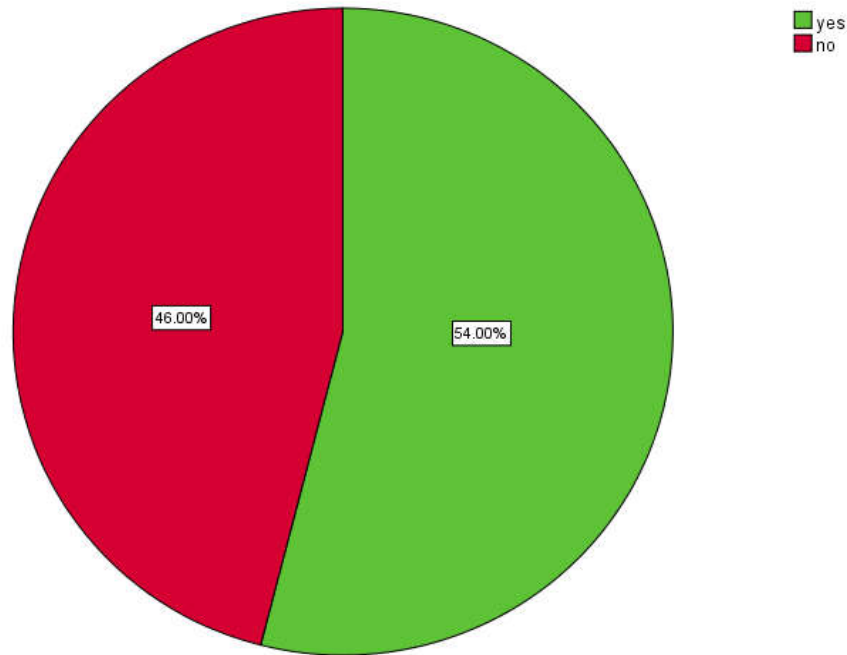


Fig. 14. Pie chart represents the responses received from the participants for the question, 'Are you aware that non-cavitated ultrasound used in second generation transdermal drug patches are limited due to its associated tissue healing?'. About 54% of the students answered yes

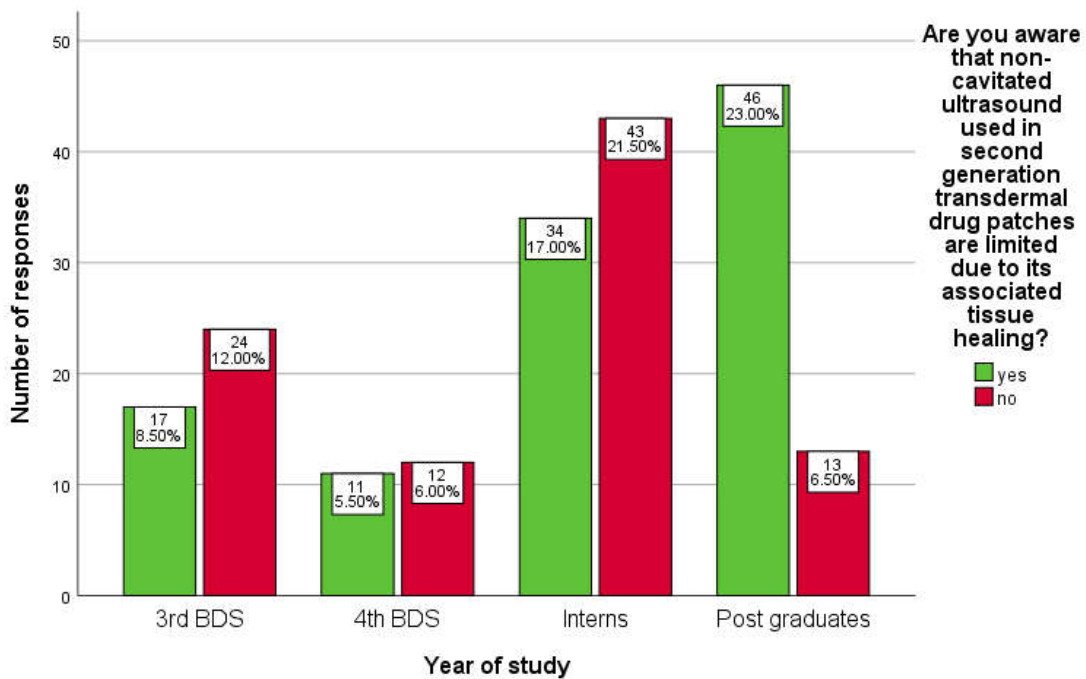


Fig. 15. Bar chart representing the association between the year of study and the responses for the question, 'Are you aware that non-cavitated ultrasound used in second generation transdermal drug patches are limited due to its associated tissue healing?'. X axis represents the year of study and Y axis represents the number of responses. Chi square test was done and it was found to be statistically significant. Pearson Chi square value = 19.594; p-value = 0.000(<0.05). Majority of postgraduates answered yes, followed by interns

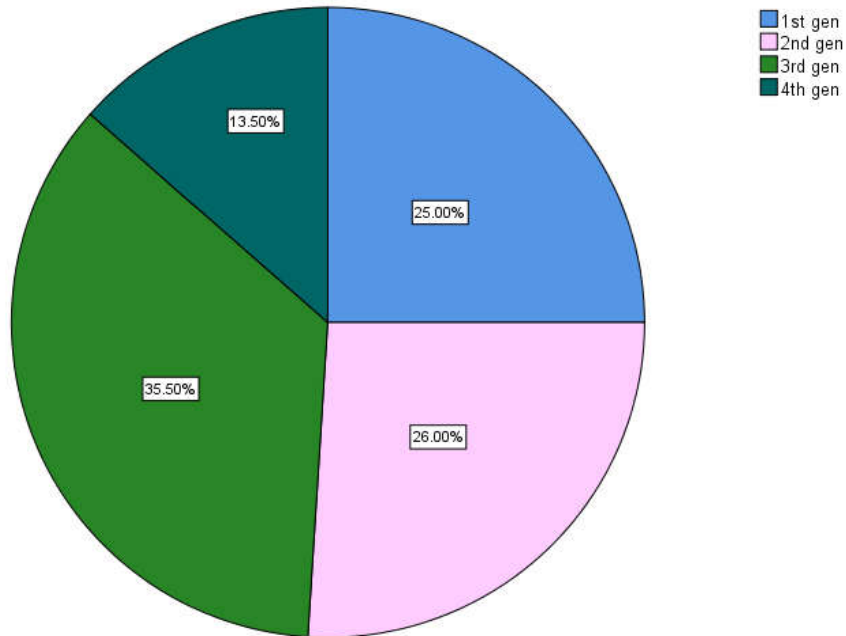


Fig. 16. Pie chart represents the responses received from the participants for the question, 'Microdermabrasion, microneedles and thermal ablation are used for delivery of which generation of transdermal drug patches?'. About 35.5% of the participants answered 3rd generation, which is the correct answer

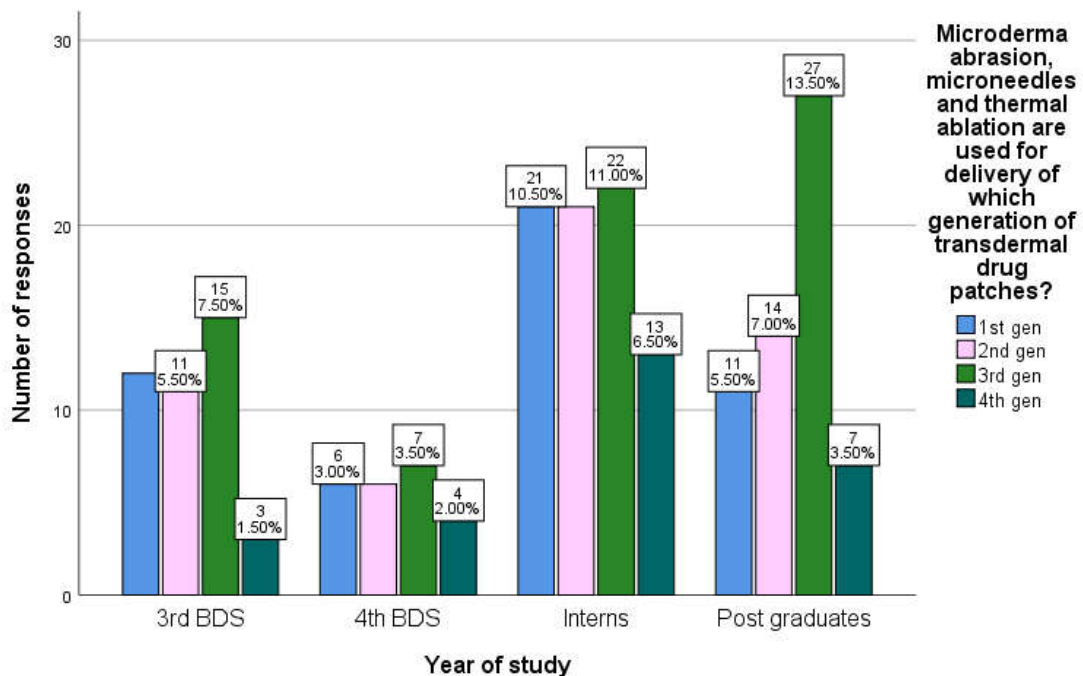


Fig. 17. Bar chart representing the association between the year of study and the responses for the question, 'Microdermabrasion, microneedles and thermal ablation are used for delivery of which generation of transdermal drug patches?'. X axis represents the year of study and Y axis represents the number of responses. Chi square test was done and it was found to be statistically not significant. Pearson Chi square value = 6.758; p-value = 0.662(>0.05). Majority of postgraduates knew the correct answer which is 3rd generation

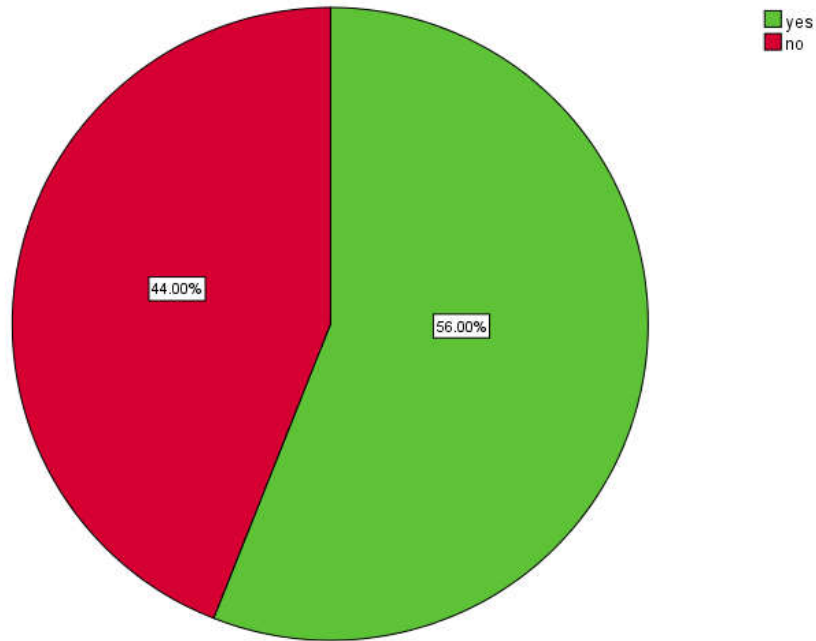


Fig. 18. Pie chart represents the responses received from the participants for the question, 'Are you aware that controlled delivery of drugs through the skin can reduce the drug spike concentration?'. About 56% of the students answered yes

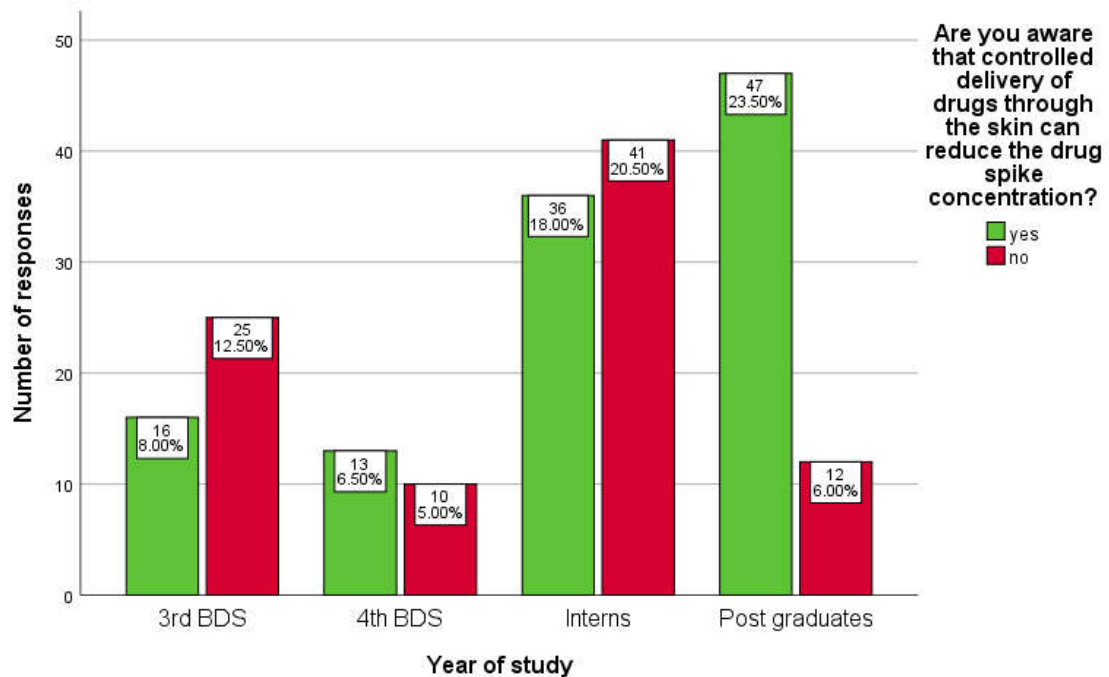


Fig. 19. Bar chart representing the association between the year of study and the responses for the question, 'Are you aware that controlled delivery of drugs through the skin can reduce the drug spike concentration?'. X axis represents the year of study and Y axis represents the number of responses. Chi square test was done and it was found to be statistically significant. Pearson Chi square value = 20.875; p-value = 0.000(<0.05). Majority of postgraduates answered yes, followed by interns

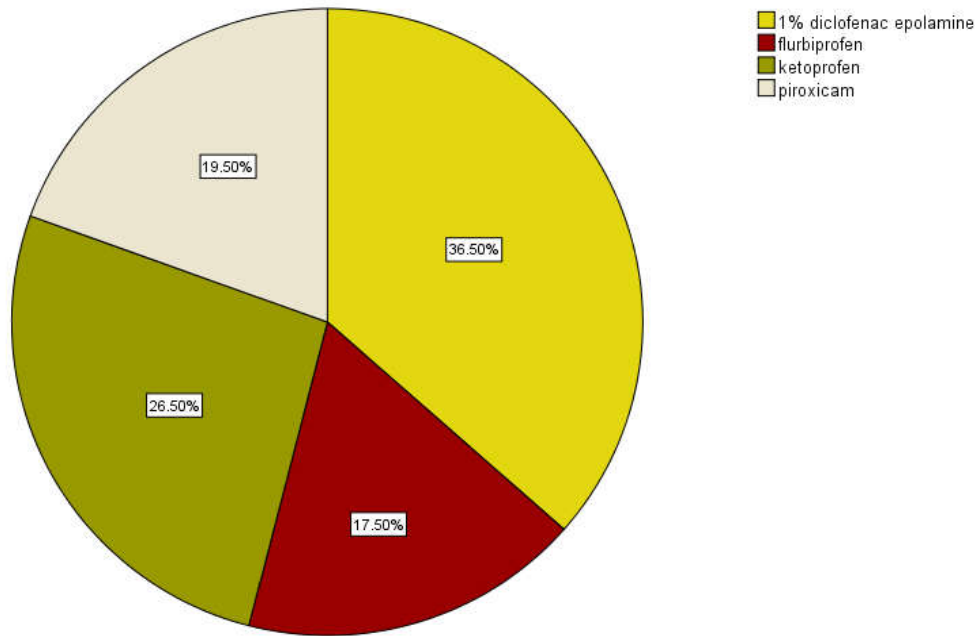


Fig. 20. Pie chart represents the responses received from the participants for the question, 'Which is the most common NSAID patch?'. About 36.5% of the participants answered 1% diclofenac epolamine, which is the correct answer

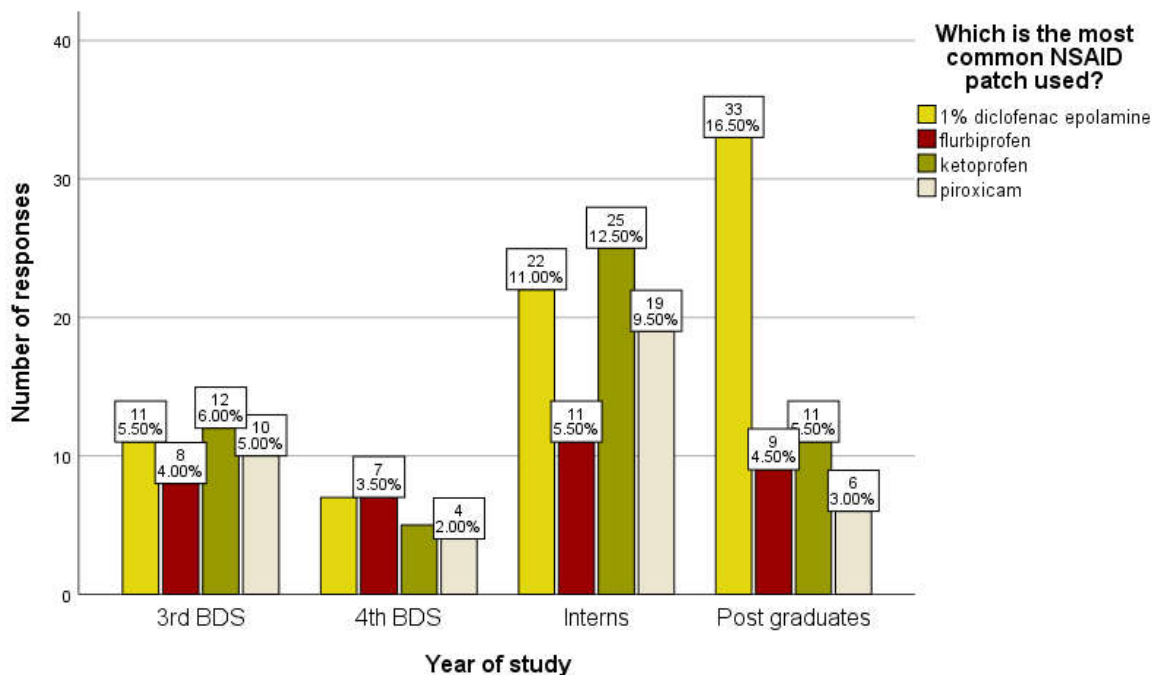


Fig. 21. Bar chart representing the association between the year of study and the responses for the question, 'Which is the most common NSAID patch?'. X axis represents the year of study and Y axis represents the number of responses. Chi square test was done and it was found to be statistically not significant. Pearson Chi square value = 18.602; p-value = 0.291(>0.05). Majority of postgraduates knew the correct answer which is 1% diclofenac epolamine

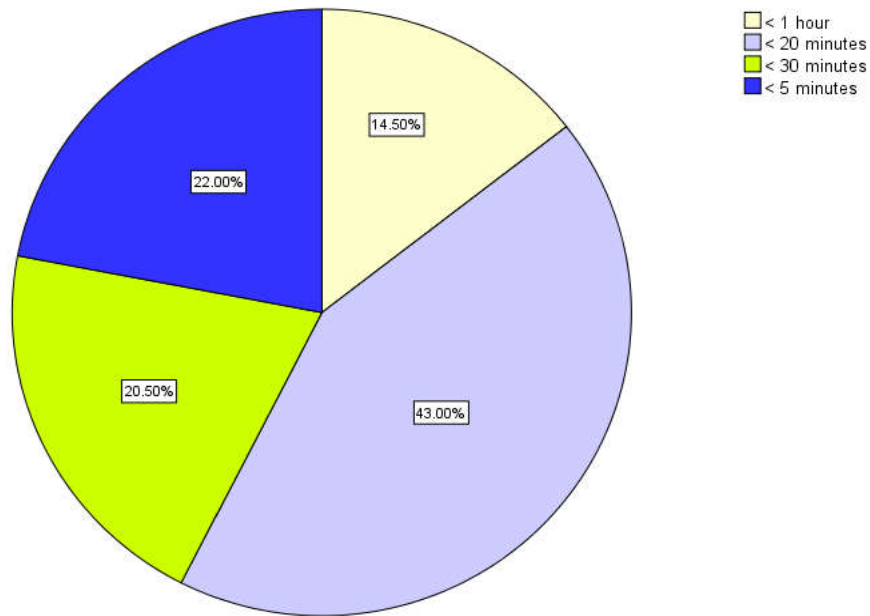


Fig. 22. Pie chart represents the responses received from the participants for the question, 'How long does it take for local anaesthetic transdermal drug patches to provide anaesthesia?' About 43% of the participants answered < 20 minutes, which is the correct answer

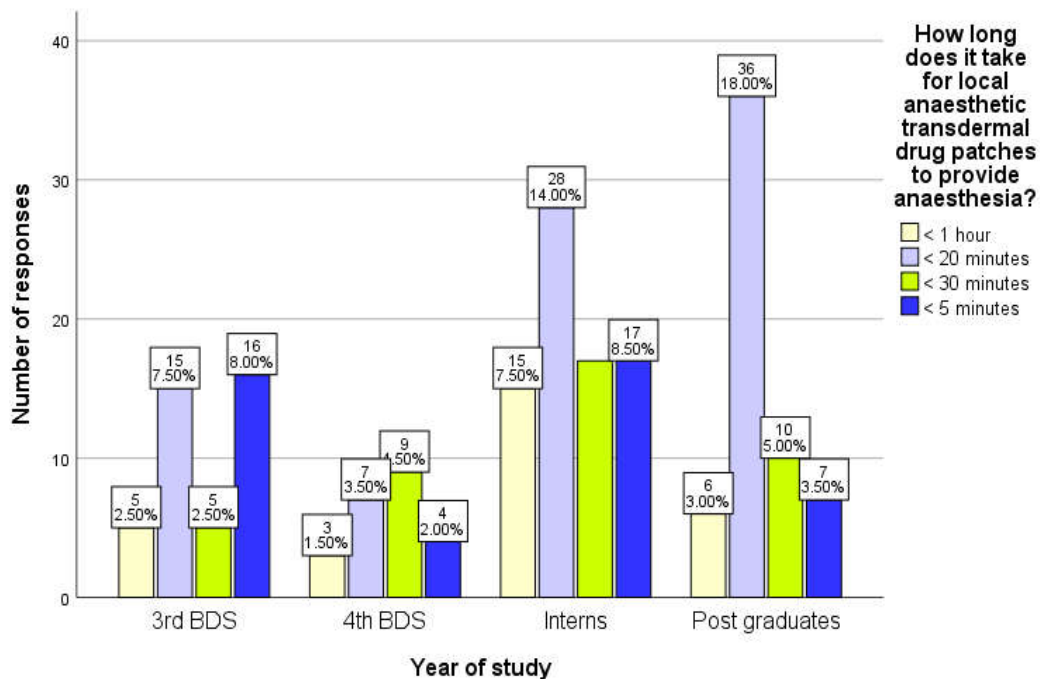


Fig. 23. Bar chart representing the association between the year of study and the responses for the question, 'How long does it take for local anaesthetic transdermal drug patches to provide anaesthesia?'. X axis represents the year of study and Y axis represents the number of responses. Chi square test was done and it was found to be statistically significant. Pearson Chi square value = 22.581; p-value = 0.007(<0.05). Majority of postgraduates knew the correct answer which is < 20 minutes

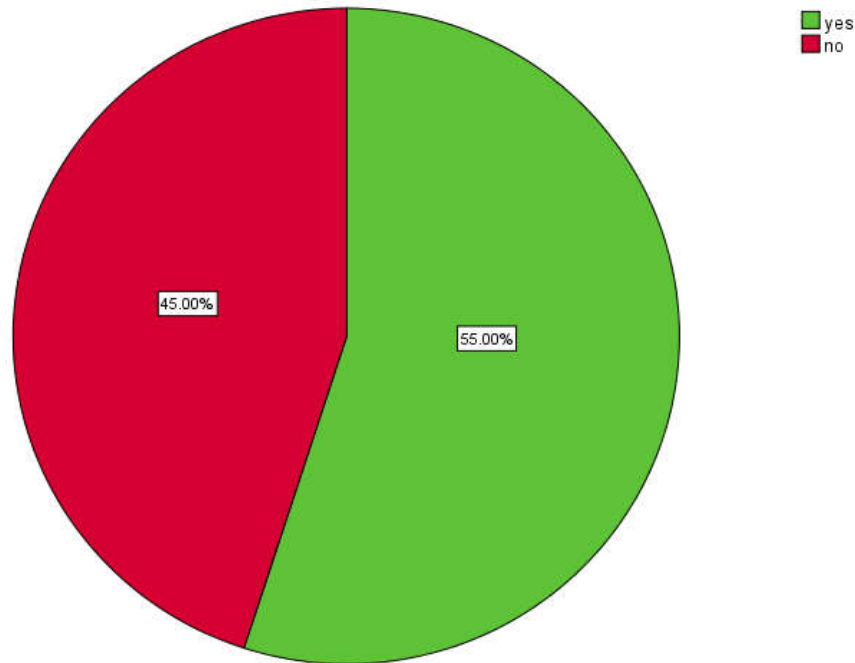


Fig. 24. Pie chart represents the responses received from the participants for the question, 'Are you aware that capsaicin dermal patches should not be used on open wounds?' About 55% of the students answered yes

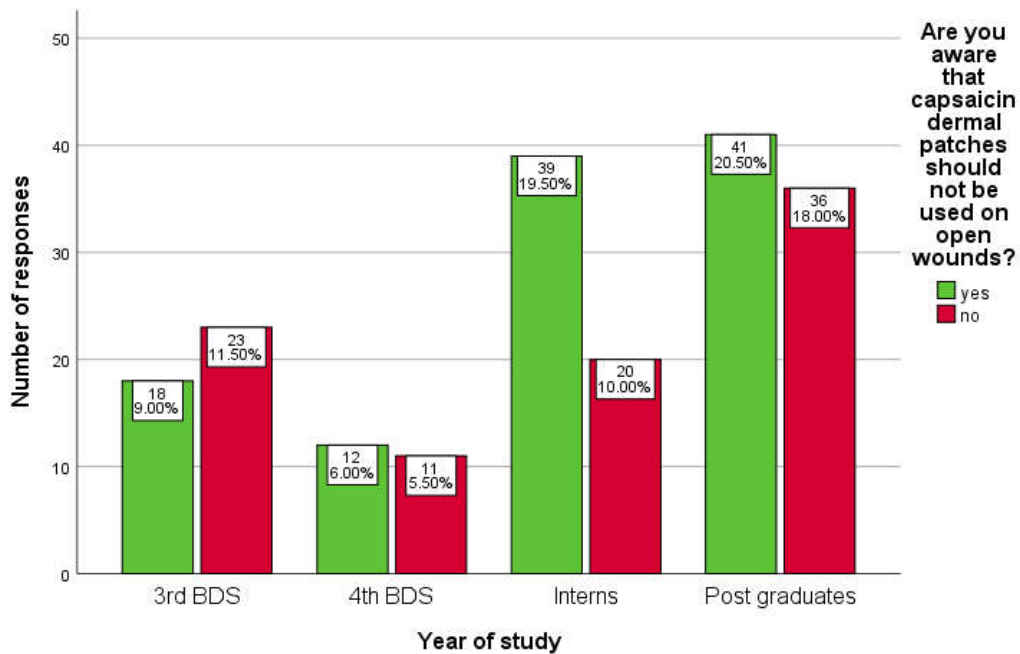


Fig. 25. Bar chart representing the association between the year of study and the responses for the question, 'Are you aware that capsaicin dermal patches should not be used on open wounds?'. X axis represents the year of study and Y axis represents the number of responses. Chi square test was done and it was found to be statistically not significant. Pearson Chi square value = 5.148; p-value = 0.161(>0.05). Majority of postgraduates answered yes, followed by interns

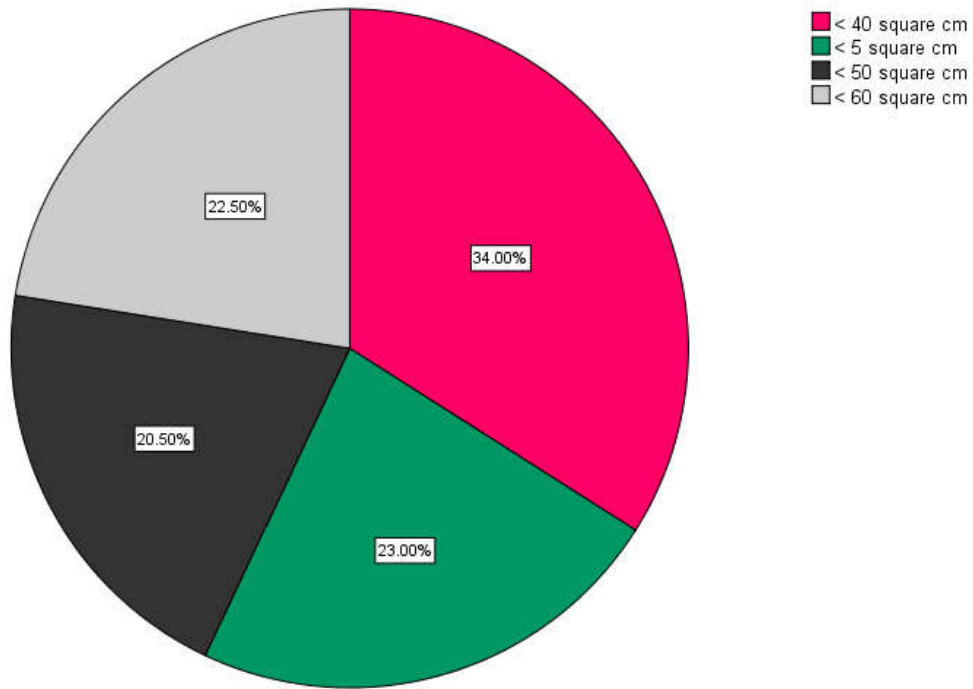


Fig. 26. Pie chart represents the responses received from the participants for the question, ‘What is the ideal size of a transdermal drug patch?’. About 34% of the participants answered < 40 cm², which is the correct answer

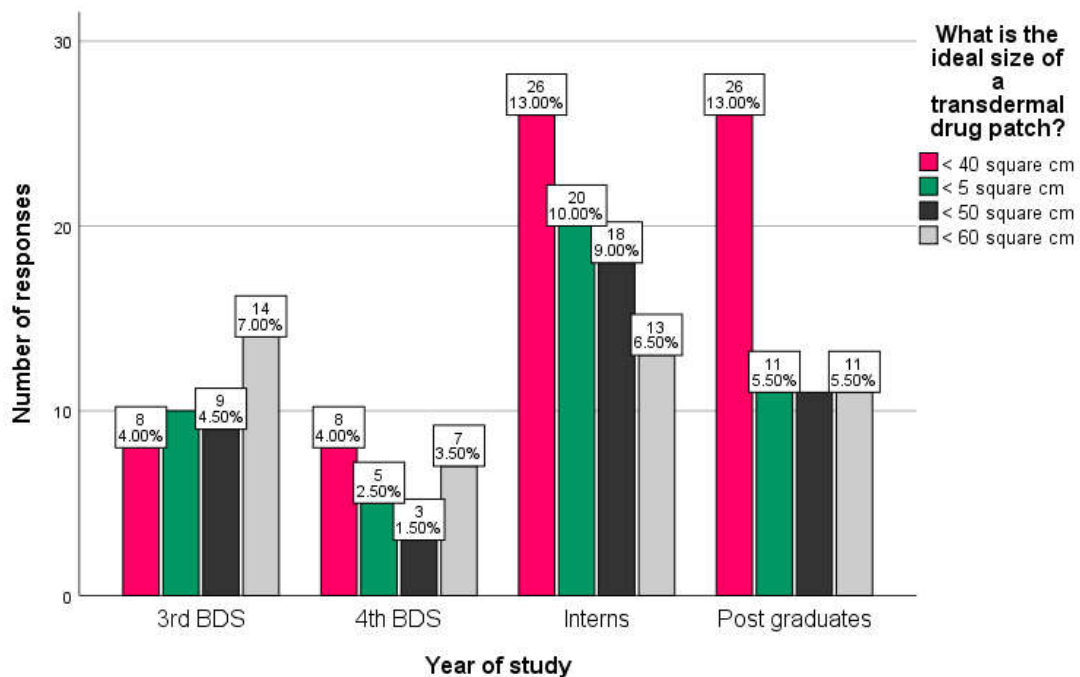


Fig. 27. Bar chart representing the association between the year of study and the responses for the question, ‘What is the ideal size of a transdermal drug patch?’. X axis represents the year of study and Y axis represents the number of responses. Chi square test was done and it was found to be statistically not significant. Pearson Chi square value = 10.729; p-value = 0.290(>0.05). Majority of postgraduates knew the correct answer which is < 40 cm²

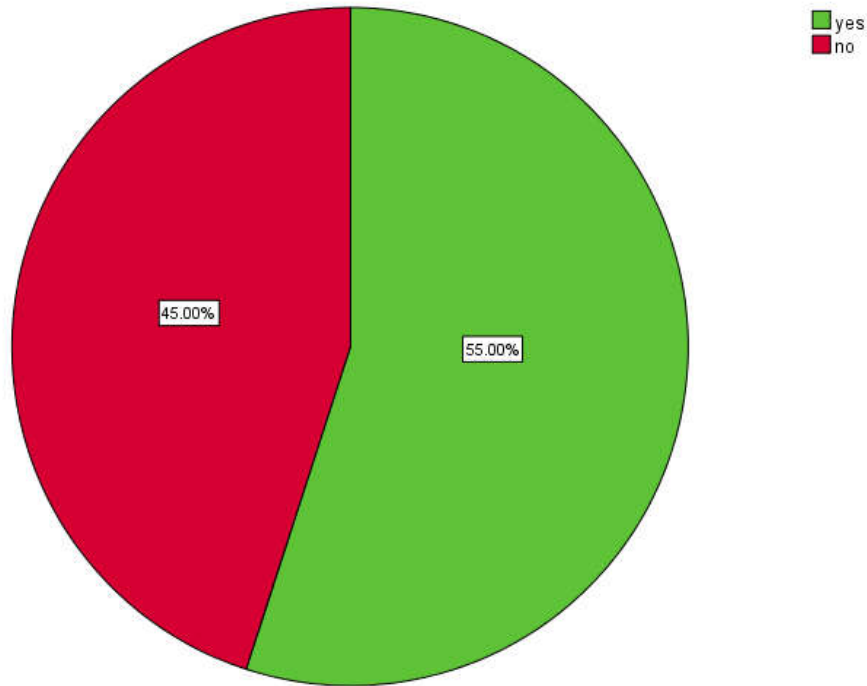


Fig. 28. Pie chart represents the responses received from the participants for the question, 'Are you aware that scopolamine was the first transdermal drug patch to be used against motion sickness?'. About 55% of the students answered yes

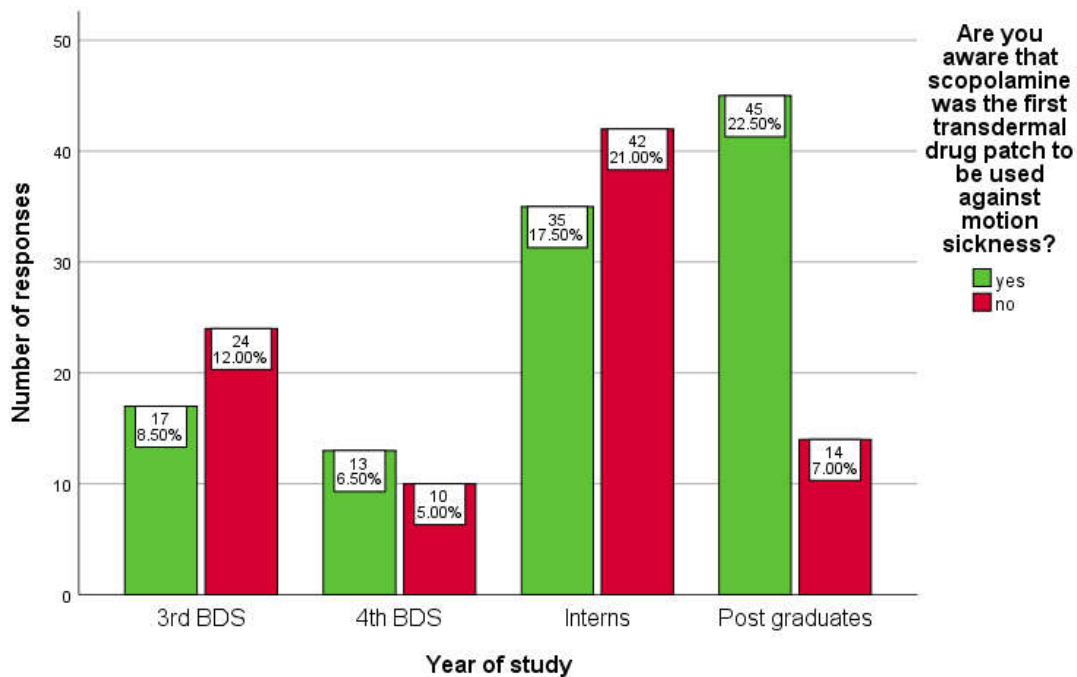


Fig. 29. Bar chart representing the association between the year of study and the responses for the question, 'Are you aware that scopolamine was the first transdermal drug patch to be used against motion sickness?'. X axis represents the year of study and Y axis represents the number of responses. Chi square test was done and it was found to be statistically not significant. Pearson Chi square value = 16.678; p-value = 0.001(<0.05). Majority of postgraduates answered yes, followed by interns

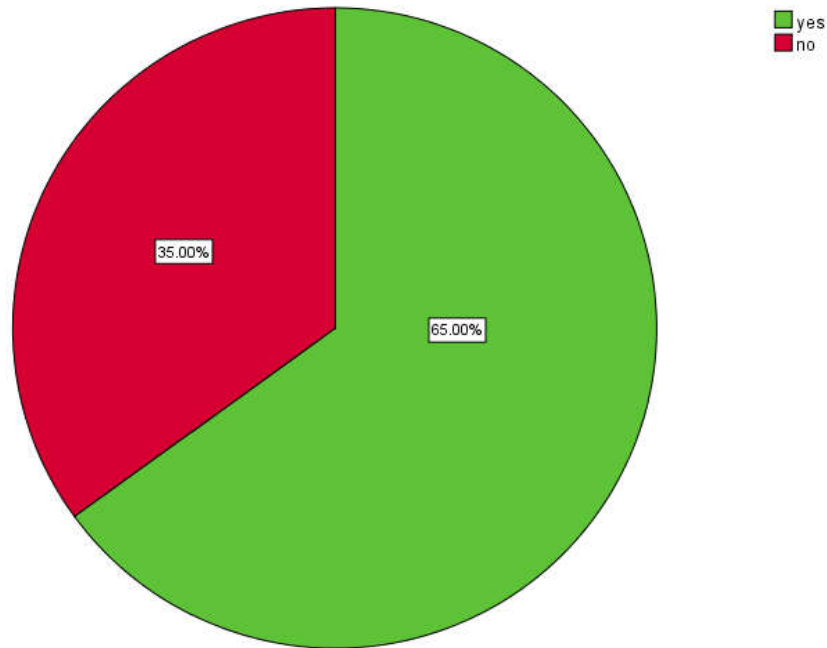


Fig. 30. Pie chart represents the responses received from the participants for the question, 'Are you aware that the most common side effect of transdermal drug patches is contact dermatitis?' About 65% of the students answered yes

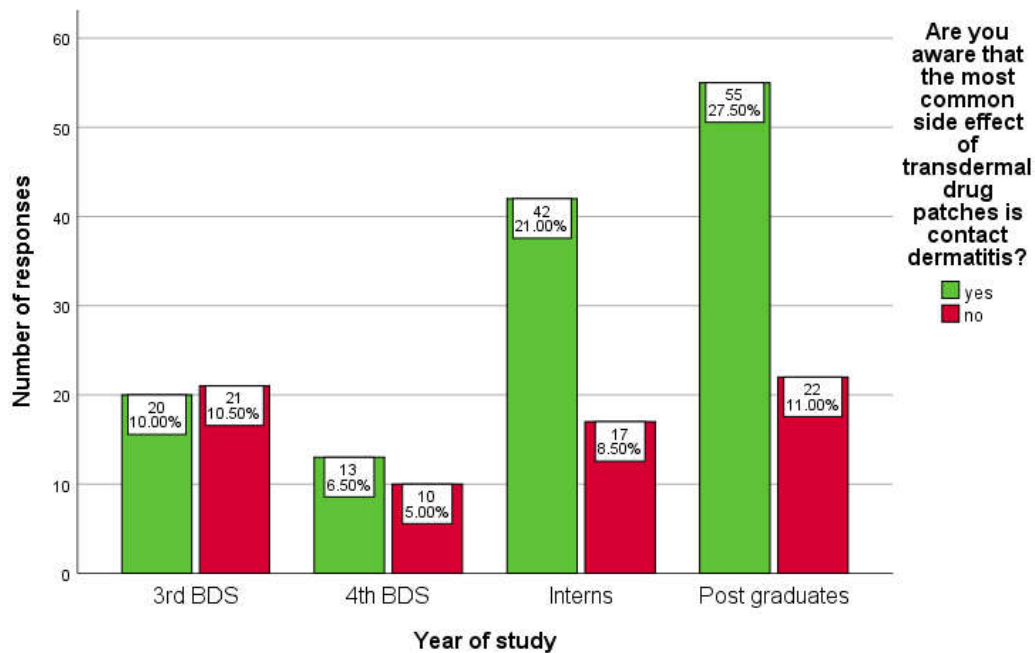


Fig. 31. Bar chart representing the association between the year of study and the responses for the question, 'Are you aware that the most common side effect of transdermal drug patches is contact dermatitis?'. X axis represents the year of study and Y axis represents the number of responses. Chi square test was done and it was found to be statistically not significant. Pearson Chi square value = 7.859; p-value = 0.491(>0.05). Majority of postgraduates answered yes, followed by interns

4. DISCUSSION

This study was done to evaluate the level of awareness of transdermal drug patches among dental students, including both undergraduates and postgraduates. Considering the responses, it can be interpreted that the knowledge regarding transdermal patches 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 side effects associated with the usage of transdermal drug patches.

Transdermal therapeutic systems are defined as self-contained, discrete dosage form which when applied to intact skin delivers the drug through the intact skin at a controlled rate to the systemic circulation and maintains the drug concentration within the therapeutic window for prolonged periods of time. Recently, the use of transdermal patches for pharmaceuticals is limited because only a few drugs have proven to be effectively delivered through the skin. They can be used as an alternative route of administration for patients who cannot tolerate oral dosage forms [24]. About 76% of students in our study were aware of this and about 80% of students were aware of its increased bioavailability. These drugs avoid first-pass metabolism because it bypasses the liver. A simplified regimen leads to improved patient compliance and reduced inter and intra-patient variability [4].

In our study, only 41.5% knew about the various generations of transdermal drug patches and the awareness about the different modifications in each generation was generally below average among dental students. Transdermal patches can be categorized into three categories - First generation, second generation, and third generation. The first generation transdermal patch design consists of the drug in a reservoir that is enclosed on one side with impermeable backing and adhesive, which contacts the skin. However, they are limited primarily to the skin barrier that is the stratum corneum. Hence, the drugs should be of low molecular weight, lipophilic, and efficient at low doses [8]. Second generation transdermal patches increase the skin permeability, reduce damage to the deeper tissues, and provide better transport into the skin. Certain modifications such as chemical enhancers, non-cavitation ultrasound and iontophoresis have disturbed the balance in the

approach to increase the delivery and also protect the deeper tissues at the deeper level [25]. The third generation transdermal patches include microneedles, thermal ablation, and microdermabrasion that have been experimented in human clinical trials to deliver the macromolecules, therapeutic proteins, and vaccines [10].

About 56% of dental students were aware that controlled delivery of drugs through the skin can reduce the drug spike concentration. A transdermal patch uses a special membrane to control the release rate at which the liquid drug-containing patch reservoir can pass through the skin and into the bloodstream [26]. Transdermal delivery not only provides controlled, constant administration of the drug, but also allows continuous input of drugs with short biological half-lives, and eliminates pulsed delivery into systemic circulation which is responsible for undesirable side effects [27]. NSAIDs are popular drugs, which are used to treat both chronic and acute musculoskeletal conditions. They have the advantage of local action without developing central adverse effects and cognitive defects. Different commercially available NSAID patches are ketoprofen, diclofenac, flurbiprofen, and piroxicam patches. The most common NSAID patch used is 1% diclofenac epolamine, licensed to treat acute pain in epicondylitis and ankle sprains. A recent review supports that it is being used to help in topical and systemic effects. A reduction in pain scores was demonstrated after 3 hrs in patients with ankle sprains [11]. As diclofenac first appears in the plasma at a mean of 4.5 hrs, after topical application, it is thought that the patch must provide analgesia via a local action. After patch removal, due to a local reservoir effect, the plasma diclofenac half-life is ~9–12 h, compared with 1-2 hrs after oral intake. Systemic transfer after removal of the patch compared with oral forms of diclofenac is only about 2%, so systemic side effects are very rare [28]. Only 36.5% of students in our study had knowledge of this.

Topical anesthetics have been developed to counteract the discomfort and pain during venipuncture and intravenous catheter insertion [29]. It has fewer side effects and is easy to apply. For proper utility in practice, it should have a direct local action with limited systemic effect [30]. Transdermal technologies promote the flow of several sizes of various molecules that move through the skin barrier, via the transient microchannels which help provide

greater anesthesia in <20 minutes [31]. It has better tolerance with side effects on the cutaneous area. About 43% of students were aware of this fact. About 55% of students were aware that capsaicin dermal patches should not be used on open wounds. Capsaicin is available in an 8% dermal patch, and it contains 179 g of capsaicin. It is extremely lipophilic and gets easily absorbed into the epidermal and dermal layers. This patch is also known as NGX 4010. Studies show effective results up to 12 weeks after the application of the patch, especially for postherpetic neuralgia [32].

The ideal properties of the transdermal drug delivery system include a shelf life of up to 2.5 years, patch size less than 40 cm², should be clear or white color, should be non-irritating to the skin, should have a consistent pharmacokinetic and pharmacodynamic profile over time [33]. However, only 34% of students were aware of this. The majority of the students were aware of the side effects of using transdermal drug patches. Skin reactions, skin discoloration, allergies, disruption of the skin-barrier layers, and blood level alterations are the pitfalls of this technique. Skin reactions, including contact dermatitis, are the most common for certain patches but also depend upon the individual using them. Nonetheless, the majority of drugs' adverse reactions (ADRs) are mild in nature and the cessation rate is low (1.7–6.8%). At times, the TDDS can cause local edema, skin irritations, and burns, which may be due to the drug's nature, reactivity, nature of the formulation, the patch's paste material, or other excipients, delivery enhancers and adhesives present or used and retained in the TDDS preparations. Therefore, the transdermal patches have several limitations and they may act as a hindrance to the effective delivery of a variety of drugs [34].

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 transdermal drug patches among all dental students. Educational

workshops, conferences, and continuing dental education programs are essential for both undergraduates and postgraduates to improve their knowledge regarding various transdermal drug patches, their mechanism, and their adverse reactions.

CONSENT

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

ETHICAL APPROVAL

Ethical approval was obtained from the institution's ethical committee

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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