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Prevalence Of Hyperpigmentation Disorders In Fitzpatrick Skin Types

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Abstract: **Hyperpigmentation is a multifactorial skin condition that mainly affects individuals with Fitzpatrick skin types III-VI.UV radiation from sunlight is the main trigger for hyperpigmentation, which is also associated with increased risk of skin cancer. Tobacco smoking and air pollution, along with several other risk factors, contribute to the development of hyperpigmentation. Despite it being very prevalent and also having a high psychosocial impact, it is an underrepresented condition in dermatological research. The main objective of this cross-sectional study is to assess the prevalence, patterns, and its psychosocial impact across individuals of different skin types. It also significantly affects the quality of life, especially in individuals with darker skin tones. Awareness of the treatment options and their affordability should be addressed to the general public.**

Keywords – Hyperpigmentation Disorders, Fitzpatrick Skin Types, Melasma, Post-Inflammatory Hyperpigmentation.

I. Introduction

Hyperpigmentation is a multifaceted problem affecting a vast number of people, more so individuals with skin of colour (Fitzpatrick skin types III–VI). It is a common skin condition where certain areas of the skin become darker due to an excess production of melanin. Two major factors have been associated with the pathophysiology · One is inflammation, which contributes to the damage of the basal layer of the epidermis and acts as a trigger for melanocytes to release melanosomes containing pigment to the surrounding skin cells · Secondly, abnormal, and excessive pigment deposition which is frequently linked to damage the upper layers of the skin, specifically within the basement membrane and basal keratinocytes. Individuals with darker skin pigmentation might experience a reduced cutaneous microvascular function, together with low-grade chronic production of pro-inflammatory cytokines and so changes in the inflammatory profiles, which can also be enhanced by additional extrinsic factors, can lead to severe hyperpigmentation in dark skin. [1][2]. Melanin exists in two forms: Eumelanin (brown-black pigment) and Pheomelanin (yellow-red pigment). Eumelanin provides photoprotection by absorbing UV radiation and neutralising free radicals but chronic stimulation can lead to persistent pigment deposition and they degrade slower making the pigmentation more persistent, hence individuals with darker skin tones are more prone to hyperpigmentation due to more active melanocytes, more efficient melanin transfer and more production of eumelanin in skin naturally [2].

Types of hyperpigmentation include melasma, PIH, sunspots, acanthosis nigricans, lentigines, vitiligo, albinism, pityriasis alba, maskne, and more [3][4]. Maskne is acne caused by the frequent use of masks. Their long-term use leads to skin irritations, dermatitis, acne formations, leaving back acne scarring and hyperpigmentation. Multiple mechanisms can contribute to the

disruption of the skin barrier due to mask wear which including friction and sweating, local temperature rise causing an increase in sebum production, increased skin humidity that can increase the amount of skin squalene, increased skin pH, and trans epidermal water loss [3]. Interestingly, there exist a not so sweeter side of mango as they can also act as a trigger for PIH since they contain urushiol (a lipid soluble allergen) which is seen to cause a type IV hypersensitivity reaction releasing cytokines leading to conditions like contact dermatitis which can leadto inflammation, melanocyte activation and then to post-inflammatory hyperpigmentation [5].

Several risk factors that participate in the development and progression of hyperpigmentation. Among these, UV radiation from sunlight stands out as the main environmental catalyst, as it stimulates melanocyte activity, increasing melanin production as a protective response [2][4][6]. UV exposure is also associated with an elevated risk of skin cancer [7]. In addition to UV radiation, other external factors like tobacco smoking and air pollution [8], and the inadequate use of sunscreen [6][7], further worsen pigmentary changes. Allergic reactions, particularly in conditions like contact dermatitis, triggered by exposure to allergens like urushiol (found in plants like poison ivy, oak, or sumac), lead to inflammation of the skin, resulting in PIH [4][5]. Moreover, the COVID-19 pandemic has had a significant impact on skin health. Prolonged mask-wearing is associated with skin conditions such as acne (referred to as "maskne"), along with darkening of the skin and scarring. These issues are likely due to increased sweating, friction, altered skin temperature, and pH imbalances, especially in areas like the cheeks, chin, and jawline [3]. Beyond environmental triggers, hormonal changes also play a pivotal role in pigmentation disorders. Changes in estrogen and progesterone levels, such as those occurring during pregnancy, menopause, or with the use of oral contraceptives, along with genetic predisposition, endocrine dysfunction, and cosmetic contact sensitivity, specifically to thiomersal (a mercury-based preservative) associated with increased incidence of melasma. These factors primarily affect women and typically involve the facial area [2][4][8][9]. A variety of medications have been associated with the development of hyperpigmentation. These include antibiotics, antihypertensives, anticonvulsants, NSAIDs, antineoplastics, psychoactive agents, and medications containing heavy metal components [10]. In addition, cyclosporine, an **i**mmunosuppressant, has been shown to indirectly stimulate melanocytes, contributing to drug-induced hyperpigmentation [11]. Moreover, deficiencies in essential vitamins, particularly vitamin B12, often present as pigmentation on hands, feet, knuckles, and creases, flexural areas [12][13]**.** Additional deficiencies, including vitamin B3, vitamin D, vitamin C, and minerals such as iron (which is notably associated with melasma), are also recognized contributors to HP [14][4]. Furthermore, chronic inflammatory skin conditions such as psoriasis and trauma lead to PIH as a part of the healing process [15]. Lastly, several genetic and physiological factors are associated with periorbital hyperpigmentation (POH**).** These include a positive family history (following a dominant autosomal inheritance pattern), anemia, irregular menstruation, and lifestyle factors such as prolonged television watching. POH is commonly observed in women over 36 years and during adolescence, which appears to be a key period for onset [16][17].

Despite significant advancements in our understanding of hyperpigmentation, especially in areas related to its etiology and treatment, there are still significant gaps in current research [1][18]. One major gap is the understudied histopathological aspects of PIH in various ethnic groups [1]. Additionally, the underrepresentation of minority ethnic communities in clinical trials impedes the understanding of melasma trends in these populations. Although melasma is more common in men in some regions (like Brazil and India), men are less likely to seek treatment or take part in clinical trials [19]. This leads to an incomplete understanding of its epidemiology. Furthermore, a deeper understanding of structural and immunological

differences in light and dark skin types is essential for developing tailored treatments for hyperpigmentation [1]. While most of the studies center on melasma, despite the prevalence of other forms of PIH, POH, and drug-induced hyperpigmentation [10][16][17]. In addition to these issues, sunscreen usage is poor in rural and low-income regions, often due to a lack of awareness, further exacerbating pigmentation disorders [6][7]. Psychosocial impacts, such as the effects of facial hyperpigmentation on mental health and self-esteem, are severely underrepresented in current literature [20]. From a treatment perspective, long-term

Safety and ineffectiveness of combination therapies, laser treatments, and topical medications like hydroquinone occur often due to unexplored large-scale trials, especially in darker skin individuals [16][18][21][22][23].

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Objectives

In this cross-sectional study, we investigate the underlying causes, prevalence, etiology, and demographic patterns of hyperpigmentation in Fitzpatrick skin types. It also emphasizes the psychological and emotional effects of hyperpigmentation. Moreover, the structural and immunological differences between light and dark skin types and their implications for developing more specialized treatments. It also assesses the long-term safety and effectiveness of various treatment methods along with sunscreen usage and public awareness. Lastly, the paper delves into molecular mechanisms underlying hyperpigmentation while addressing the lack of research on other forms of hyperpigmentation, such as drug-induced pigmentation and POH.

II. Methods and Materials

This cross-sectional study was conducted in order to assess and form an elaborate understanding of the Trends of hyperpigmentation in different Fitzpatrick skin types.

The methodology incorporated precise inclusion and exclusion criteria by accepting participation of individuals above 18 years of age after compliance with consent, with Gmail ID being the only sole requirement needed for providing answers to the survey, thereby maintaining anonymity of the participants as well as avoiding bias. One response per Gmail ID was kept as a limit to ensure that each participant gets only a single opportunity to respond to the questions.

The time frame designated for the course of acquiring data was from March 1st, 2025, to April 7th, 2025, and Google Forms were used in a multiple-choice checkbox format where participants would select an appropriate option for the questionnaire as input answers.

The questionnaire included inquiries regarding demographics like Age, Gender, Ethnicity, the current place of residence, and then questions about skin type like what kind of Fitzpatrick Skin Type (1-6), specific skin type (Normal, Combination, Oily, Dry, Sensitive), and a question whether the participant currently has or previously had hyperpigmentation, which when answered with a no would end the survey and a response with a yes would be followed by questions regarding their prevalence and triggers, medications that lead to their hyperpigmentation, their treatment and effectiveness, its impact on their quality of life and about general awareness and interest.

In order to acquire results, it was extensively circulated across many social media sites like WhatsApp, Telegram, Reddit, Instagram, etc, and a paid Instagram story promotion was also conducted to optimize the reach of the survey.

The study size consisted of a sample population of 1514 individuals recorded with the majority being South Asian descent (66.2%), thereby integrating all six Fitzpatrick skin types. 51.7% of the respondents belonged to the age group 18-24 since young adults are prone to acne and PIH, making them vulnerable to developing the condition. 56.5% and 43.5% were the percentages of females and male participants, respectively.

A coordinated and detailed search was conducted across multiple platforms such as PubMed, Google Scholar, Research Gate, Cosmoderma, etc in order to select articles for the theoretical (literature) aspect of the study by the authors. The key highlighted words used for choosing these articles included- Hyperpigmentation, Fitzpatrick skin types, melasma, Post-inflammatory pigmentation, acne scar.

Independent variables of the research included the type of Fitzpatrick skin type (Type 1-6), which is the primary factor. Dependent outcome such as the prevalence of hyperpigmentation disorders (Post-inflammatory, melasma, solar lentigines, ephelides, etc.). Covariates (potential confounders/ adjustment variables) included demographic factors such as age, gender, ethnicity, Behavior/ Lifestyle factors such as sun exposure, mask usage habits, Medical history such as acne or inflammatory skin conditions, and hormonal changes. Quantitative variables were handled in such a way that age was represented as categorical variables with age brackets predefined, such as 18-24, 25-34, 35-44, 45-54, 55+.

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III. RESULTS

A total of 1515 participated in the survey, and 1514 participants consented to fill out the survey. Among them, 51.7% (n=782) of respondents were between 18-24 years, making it the largest group. Younger adults are more likely to deal with acne and post-inflammatory hyperpigmentation (PIH), which can lead to darker spots or uneven skin tone after healing. 39.2% (n=593) were between 25-34 years.

Participation of older groups was lower, where 6.3% (n=95) were between 35-44 years, 2.2% (n=34) were between 45-54 years, and 0.7% (n=10) were 55+ years.

56.3% of participants were female (n=853). Women also experience melasma and sun spots more frequently due to hormonal changes, such as during pregnancy or with the use of birth control. 43.5% of respondents were male (n= 657).

South Asians represent the largest ethnic group in the study, which includes 66.2% (n=1001) of the respondents, with the majority being Indian. They are more likely to experience post-inflammatory hyperpigmentation (PIH), caused by acne or other skin injuries. Hyperpigmentation is usually more persistent and pronounced in this group due to increased melanin production in response to inflammation.

13.7% (n=206) of the respondents were Caucasian/White. Caucasians are typically less prone to severe hyperpigmentation compared to darker skin tones. This group is often more affected by sun-induced pigmentation rather than PIH. 13.7% (n=206) of the respondents were African/black. The increased melanin production in darker skin types can cause dark spots and uneven skin tone that persists longer compared to lighter skin tones. 0.2% (n=3) of the respondents were Hispanic/Latino group and 0.5% (n=8) were Middle Eastern individuals, 0.5% (n=8) were Indigenous/Aboriginal and 0.5% (n-8) were Mixed/Other.

Graph 1- Fitzpatrick skin types

According to the survey, 14.7% of the respondents (n=222) had **Fitzpatrick Skin type I**. People in this group are highly sensitive to sunlight and typically struggle to develop a tan. 6 out of them had previous or current presence of Hyperpigmentation. According to the survey, they had sensitive, combination, and oily skin types, and hyperpigmentation mostly occurred at cheeks, chin, arms, around eyes, etc, and the majority of them stated that it could have been triggered due to sun exposures, skin damage, and hormonal changes. According to the survey, only one of them was officially diagnosed with hyperpigmentation and had undergone treatment. Some of them used over-the-counter creams (Vitamin C, Niacinamide, Alpha Arbutin), prescription creams (Hydroquinone, Tretinoin, Azelaic acid), and home remedies for the treatment

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Fitzpatrick Type II (Fair Skin), consisted of 16.7% of the sample (n = 253). Though their skin is more resilient to the sun compared to Type I, they still experience burning more often than tanning. According to the survey, 40 participants with type 1 Fitzpatrick skin type reported to have or had hyperpigmentation. Of the 37 respondents with hyperpigmentation were females, and 7 of them were males. According to the survey, they described that their skin was of oily, combination, and normal types. The majority of them had hyperpigmentation in areas like cheeks, chin, jawline, forehead, nose, neck, etc. Sun exposure, skin damage, and hormonal changes were also reported as the reasons that could have triggered the hyperpigmentation, according to the survey. These individuals had reported to have previous skin conditions like acne vulgaris, lentigines, and eczema, and one of them had medical conditions like diabetes mellitus. Some of them reported that the use of medications like Sunscreen, niacinamide, rice water serum, and itraconazole could have triggered their condition. Majority of them used over-the-counter creams (Vitamin C, Niacinamide, Alpha Arbutin), prescription creams (Hydroquinone, Tretinoin, Azelaic acid) and home remedies for their treatment, and majority of them have reported to have seen improvements with those treatments within 1- 6 months and some even in less than a month.

Fitzpatrick Type III skin, comprising 11.4% of the respondents (n = 173), includes those individuals with a moderate ability to handle sun exposure, with a mix of burning and tanning depending on the intensity and duration of exposure. According to the survey, 81 of these participants currently have or previously had hyperpigmentation. The majority of them had oily and combination skin types and had hyperpigmentation in areas like Cheeks, Forehead, Upper lip, Neck, Hands, Legs. Sun exposure, skin damage, and hormonal changes were also their major concerns that could have triggered their conditions. They reported to have had previous skin conditions like Acne Vulgaris, Melasma, PIH, Eczema, and some had other medical conditions like thyroid disorders and diabetes mellitus. Most of them treated their conditions with over-the-counter creams (Vitamin C, Niacinamide, Alpha Arbutin), home Remedies, and have seen little to mild improvements, and the majority of them were open to seeking chemical peels and lasers for the treatment. According to the survey majority of them agreed that their mental health had been affected by their condition

Fitzpatrick Type IV (Olive or Light Brown Skin), making up **24%** of the respondents (364 individuals), is the largest group in this study. This skin type is associated with a higher degree of sun resilience compared to the lighter skin types. According to the survey, 297 of them agreed to have or had hyperpigmentation, and the majority of them were of South Asian ethnicity. The majority of them faced hyperpigmentation in areas like cheeks, chin, Jawline, forehead, upper lip, neck, around eyes, hands, etc. Sun exposure, skin damage, and hormonal changes were also their expected triggers. The majority of them had previous skin conditions like Acne Vulgaris, Acne Rosacea, PIH, etc, and some of them had other medical conditions like genetic disorders (Albinism, Xeroderma), Cushing's syndrome, thyroid disorders, diabetes mellitus, etc. The majority used over-the-counter creams (Vitamin C, Niacinamide, Alpha Arbutin), home Remedies for treatment, and many failed to see any results. According to the survey, all the participants reported that they would have sought professional treatment if it were more affordable. The majority of them also reported having their confidence affected by their condition

Fitzpatrick Type V (Dark Brown Skin), representing 19.7% of the participants (n = 298), includes people who very rarely burn and tan very well. This group demonstrates a high level of protection against sunburn and has an excellent ability to tan, making it one of the most sun-tolerant skin types in the study. 141 of them have or had hyperpigmentation. The majority of them had hyperpigmentation in areas like cheeks, chin, jawline, nose, upper lip, neck, hands, arms, legs, around eyes, etc. According to the survey, sun exposure, hormone changes, and skin damage were also thought to have triggered their condition, and most of them had previous conditions like Acne Vulgaris, PIH, Acanthosis Nigricans, etc. They treated their conditions with kojic acid, retinoids, sunscreen, home remedies, etc, and the majority of them said to have achieved very little results.

Fitzpatrick Type VI (Very Dark Skin), which accounts for **13.5%** of the sample (n=204), is characterized by skin that never burns and tans easily. People with very dark skin are the least susceptible to sunburn and tend to develop deep, even tans, making them highly protected against the harmful effects of UV radiation. 157 currently have or had hyperpigmentation. The majority of them were of African/Black ethnicity. According to the survey, most of them faced hyperpigmentation in areas like Cheeks, Chin, Forehead, etc. and the majority of the possible triggers were also sun exposure, hormonal changes, genetics, etc. The majority of the respondents reported having conditions like Melasma, PIH, Acanthosis Nigricans, etc. Most of the respondents said to have used skin care ingredients like Kojic Acid, Retinoids, Sunscreen, etc, and have seen very little results with their conditions

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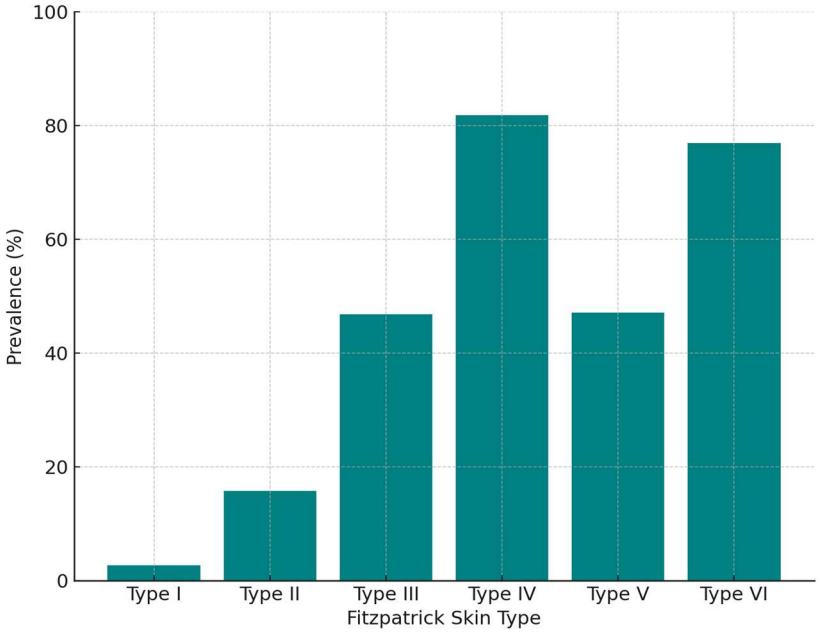
Survey analysis revealed trends in the prevalence of hyperpigmentation in different skin types. Fitzpatrick skin type I has the lowest prevalence of 2.7%(n=6 out of 222) reporting current or previous hyperpigmentation. This was increased in Fitzpatrick type II to 15.8%(n=40 out of 253), and it significantly rose to 46.8%(n=81 out of 173) in type III. The highest prevalence was found in type IV with 81.8%(n=297 out of 363), which is then followed by 77.0% in type VI(n=157 out of 204) and then 47.2%(n=141 out of 299) for type V. These results show a clear trend upwards in hyperpigmentation prevalence with the increase in skin pigmentation.



Graph 2- Prevalence of hyperpigmentation across Fitzpatrick skin types

To determine whether there is a significant association between Fitzpatrick skin types and the presence of hyperpigmentation statistically, a chi-square test of independence was conducted. We created a table with the first column as Fitzpatrick skin type, Second column as people who have marked the option "yes" in the question where we asked if they currently or previously have hyperpigmentation, and the second column for people who have marked "no" in the same question and the fourth column as total number of participants in each skin type. The observed values were compared to the expected values calculated based on marginal totals. The analysis showed a chi-square statistic of $\chi^2(5, N=1514) = 441.98$, with a p-value <0.001, indicating a highly significant association. These results confirmed us that the likelihood of experiencing hyperpigmentation significantly varies across skin types, with a higher prevalence in types IV to VI. This also supports existing dermatological evidence linking increased melanin activity and post-inflammatory response in individuals with darker skin types who have a greater risk of developing hyperpigmentation.

Table 1 - Distribution of respondents based on skin types, with and without hyperpigmentation

SKIN TYPE	TOTAL NUMBER OF RESPONDENTS	YES	NO
TYPE I	222	6	216
TYPE II	253	40	213

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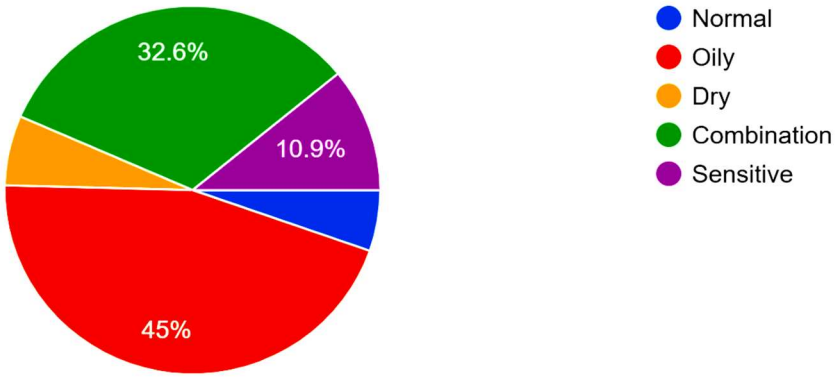
TYPE III	173	81	92
TYPE IV	363	297	66
TYPE V	299	141	158
TYPE VI	204	157	47

When asked about their particular skin type, according to the survey, a total of 45%(n = 682) had oily skin. Oily skin can be more prone to hyperpigmentation as they are more prone to acne and post acne marks, 32.6% (n=493) have combination skin, 10.9% (n= 165) have sensitive skin, 6.1 % (n=93) have dry skin and dry skin can be more sensitive and prone to irritation which trigger hyperpigmentation, 5.4 % (n= 81) have normal skin.



Graph 3 - Skin types

When asked about the areas that were most affected, according to the survey, cheeks showed the highest prevalence with 78.3% (n=569) reporting hyperpigmentation. Forehead followed closely at 76.8% (n=558). Chin was affected in 60.2% (n=438) of the respondents. Upper lip (30.5%), around the eyes (12.7%), and nose (5.9%) were less commonly reported. Jawline had the least facial hyperpigmentation at 4.5%.

In case of Non-facial regions, the neck was reported by 41.4% (n=301). Arms (11.3%), hands (9.9%), and legs (9.4%) had relatively low involvement.

56.5%(n=411) of participants said they had been hyperpigmented for one to three years. It was chronic in many cases, as evidenced by the 34.7% (n=252) who had it for longer than three years, 4.1% (n=6) had it for less than six months, while just 4.7%(n=34) said it lasted six months to a year. The majority of responders (more than 90%) reported having hyperpigmentation for more than a year, indicating that it is a chronic skin condition.

Participants were allowed to select multiple factors that they believed contributed to their condition. Sun exposure was the most frequently reported trigger, by 85.1%(n = 619). 77.3% (n=562) identified hormonal changes (e.g., pregnancy, birth control, etc.) as a contributing factor. Genetics played a significant role, as reported by 71.7% (n=521). Skin damage from acne, cuts, or burns was cited by 43.9% (n=319). Certain skincare products or treatments were believed to contribute to hyperpigmentation by 31.6% (230). Skin irritation or friction from masks or clothing was considered a cause by 3.9 (n=28)%. Medications were the least

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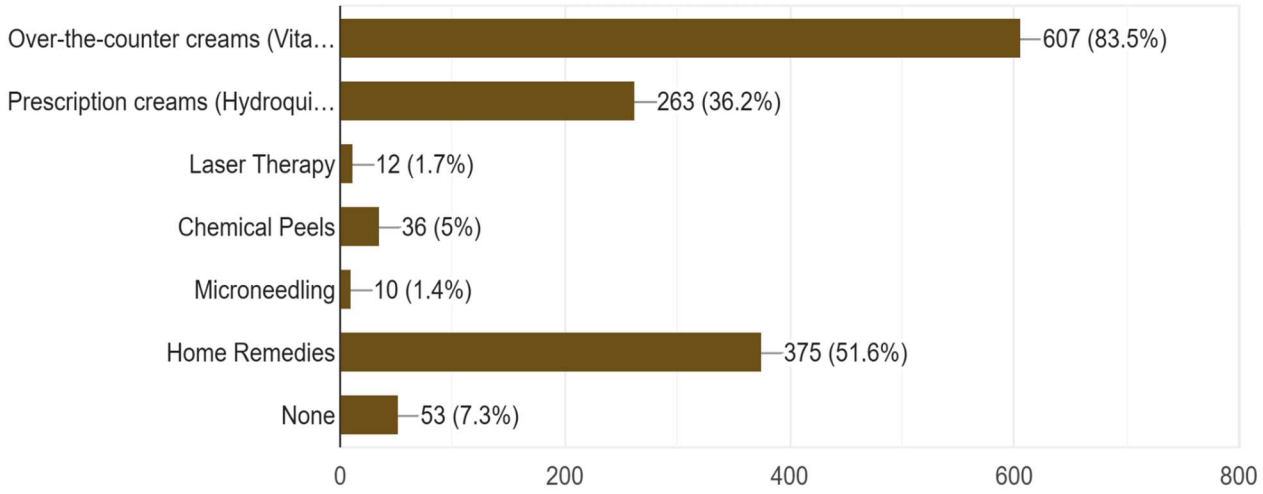
commonly reported trigger, affecting only 1.2% (n=9). Other factors were reported by 3.9% (n=28), and 8.4% (n=61) were unsure about what triggered their hyperpigmentation.

When asked about past skin issues. In 66.2% of cases, post-inflammatory hyperpigmentation (PIH) was the most frequently reported condition. The prevalence of Acanthosis nigricans was also very high, at 65.6%. 48.3% reported having acne vulgaris. 28.6% of responders have acne rosacea. Melasma was observed in 21.5% of cases. 21.7% of respondents said they had no underlying skin disorders. Lentigines, or sunspots, only affected 1.1% of people. 2.9% of people reported having eczema, while 1.4% reported having psoriasis. Among the respondents, no skin cancer instances were reported. 2.1% of people reported other ailments.

Various medical conditions can contribute to hyperpigmentation disorders. From our sampling study, 2.2% (n=16) have thyroid disorders. imbalance in thyroid hormones can disrupt the normal functioning of skin and pigment production, leading to dark patches formation mainly in the neck or around the eye region. 1.7%(n=12) had diabetes mellitus. Acanthosis nigricans is a common condition seen along with insulin resistance and type 2 diabetes, which causes dark velvety patches of skin mainly in body folds like the neck, armpits. 0.4% (n=3) have Cushing's syndrome, where high cortisol levels can lead to darkening of skin. Here, ACTH is overproduced, and it stimulates melanocytes in the skin. The hallmark of this condition is bruising, stretch marks, and skin thinning. 0.3 % (n=2) reported to have genetic disorders.

A significant majority of 92.3% (n=671) stated they took no medications that cause hyperpigmentation, 6.3% (n=43) were unsure, and 1.4% (n=10) stated they took medications that caused hyperpigmentation.

A total of 75.2% (n=547) underwent treatment for hyperpigmentation, but the rest 24.8% (n=180) did not undergo any treatment strategies



Graph 4- Treatments used for hyperpigmentation

From the extensive and wide variety of treatment methods for hyperpigmentation 83.5% (n=607) of individuals used over the counter creams like vitamin c, azelaic acid, niacinamide, kojic acid as they had high potency, easily available and were cost effective, followed by 51.6% (n=375) who used home remedies as they were really cost effective, easily accessible, safe for sensitive skin and only contains less chemicals. 36.2% (n=263) used prescription creams like hydroquinone. 5% (n= 36) used chemical peels, 1.7% (n= 12) used laser therapy, and 1.4% (n= 10) used microneedling. Even though these treatment plans had a high potency to treat hyperpigmentation, they weren't affordable and accessible to all, hence accounting for their smaller percentiles. A fraction of 7.3% (n=53) does not use any treatment plans at all.

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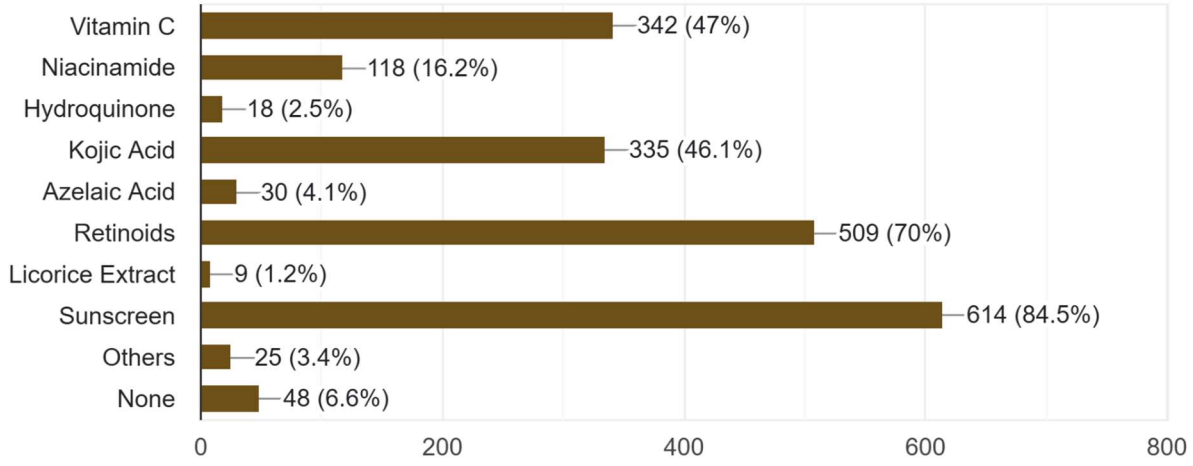
44.7% (n=325) of individuals stated they saw an improvement in their condition with the treatment regimen they followed, whereas 42% (n=305) stated they didn't see a change in their condition, and the remaining 13.3% (n=97) stated sometimes.

A majority of people, accounting for 94.1% (n=684), stated that they experienced no side effects from treatment, and the rest 5.9% (n=43) stated they experienced side effects from treatment, which can include allergic reactions, dry skin, tingling sensation, burns, or scarring.

A total of 42.5% (n=309) failed to see results in the hyperpigmentation study, possibly due to incorrect or inconsistent treatment methods or improper diagnosis. 38.1 % (n=277) took more than 6 months to see results, 8.1% (n= 59) took 1 – 3 months to see the results .6.1 % (n=44) took 3 – 6 months to see results and 5.2 % (n=38) took less than 1 month to see the results with right treatment and proper diagnosis.

A considerable majority accounting for 78.1% (n=568) were open for trying treatments like chemical peel or lasers as they have deeper penetration to layers of skin and can treat deeper pigmentation issues and can also provide with long lasting results, whereas 14% (n=102) weren't ready for such treatments and possible reasons could be cost, accessibility, a fear of developing new skin conditions or if the aggression of preexisting conditions and the rest 7.8% (n=57) were unsure.



Graph 5 -Skin care ingredients used for hyperpigmentation

From the responses gathered about the skincare ingredient used for hyperpigmentation, a vast majority, accounting for 84,5% (n=614), used **SUNSCREEN,** highlighting the importance of using sunscreen in hyperpigmentation, as UV lights can stimulate melanocytes, worsening hyperpigmentation. Immediately followed by the next key skincare ingredient **RETINOIDS** accounting for 70% (n=509) drawing light to the power of retinoids in skin cell turnover and fading dark spots and then followed by **VITAMIN C,** accounting for 47% (n=342) as they are strong antioxidants and help in attaining bright and even skin tone. **KOJIC ACID** is used by 46.1 % (n=335) as they have a skin lightening effect due to the inhibition of the enzyme tyrosinase, which is essential for melanin production, and then 16.2% (n=118) use **NIACINAMIDE,** which prevents the transfer of melanin to skin surface and have a gentle skin lightening effect. **AZELAIC ACID** used by 4.1% (n=30) as they also have the ability to inhibit tyrosinase, but was less commonly used, maybe due to the poor awareness among individuals. **HYDROQUINONE** was used only by 2.5% (n=18) despite its strong potency, but had strong side effects and availability issues in different countries. They also worked by inhibiting the enzyme tyrosinase and preventing melanin production. **LICORICE EXTRACT** was only used by 1.2% (n=9) despite its brightening and anti-inflammatory properties, possibly due to less awareness. Other skincare ingredients were used by 3.4% (n=25), and none were used by 6.6%(n=48).

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From concluding the effect of hyperpigmentation affecting confidence of individual 44.6% (n=324) stated “SOMEWHAT”, 40.2% (n=292) stated “VERY LITTLE”, 8.9% (n=65)“GREATLY “ making them avoid social gatherings, developing a fear of speaking in public thinking of getting too much attention and being prone to judgement and affecting people’s daily routines and making people feel like hyperpigmentation more than a skin concern to a personal issue affecting social and psychological aspects of an individual's life and the rest 6.3%(n=46) stated “NOT AT ALL”.

A total of 49.7% (n=361) responded “NO” to the situation of hyperpigmentation making them avoid social events whereas 42.2% (n=307) responded “YES” and the concerns could have been getting judged by society, stigma around having visible skin issues and the rest 8.1% (n=59) responded sometimes.

A total of 46.2% (n=336) stated that hyperpigmentation haven’t affected their mental health whereas in 44.8% (n=326) stated that hyperpigmentation affected their mental health which had a toll on their self esteem, confidence, fear of being getting judged by society which can leads to anxiety and isolation and can have a huge impact on the quality of a person’s life affecting both personal and professional career and the rest 8.9% (n=65) responded sometimes.

A bulk of respondents, 95% (n=691), were ready to seek professional treatment if it were more affordable, and the rest 5% (n=36) weren’t ready, maybe due to privacy concerns, cultural or social factors, and stigma associated with having cosmetic procedures.

A total of 82.5% (n=600) stated “YES” that they were open to participate in a hyperpigmentation treatment study and 10.6% (n=77) stated “MAYBE” and the rest 6.9% (n=50) stated “NO” and could have been due to the possible reason of having a discomfort in sharing personal skin condition or being sceptical about the treatment regime.

Survey analysis on hyperpigmentation being fully treated was presented with an overwhelming “YES” response by 82.5% (n = 600), “UNCERTAINTY” stated by 14.6% (n=106), and “NO” by 2.9 % (n=21) due to limited access to the new advanced treatment regimes.

IV. Discussion

4.1 Key findings and Interpretation

This study shows higher pigmentation disorders in individuals with Fitzpatrick skin types IV, V, and VI, as they have the most cases. This also aligns with the previous evidence suggesting that the individuals with darker skin types are more susceptible to pigmentation changes due to increased melanocyte activity, higher tyrosinase expression, and also differences in the dermal-epidermal junction [1].

Among the ethnic groups, South asians are the largest subgroup in the survey, particularly indian origin participants, which influenced the skewed distribution of skin types and resulted in higher prevalence of post-inflammatory hyperpigmentation(PIH), Melasma, and acanthosis nigricans. These conditions have been well documented in individuals with darker skin tones due to their enhanced inflammatory response and greater melanosome transfer during an injury [1].

The majority of the respondents reported that their hyperpigmentation has lasted more than 1 to 3 years or more indicating the persistent and chronic nature of these disorders. The study also found that pigmentation more commonly affected the cheeks, forehead, and the chin, which is consistent with sun-exposed facial areas [1].

The triggers reported most commonly were sun exposure, hormonal changes, and genetic predisposition. This also helps reinforce the previous findings that UV radiation and hormonal imbalances, more particularly in women, play an important role in the overproduction of melanin [2][4][6][7].

The study also highlights the psychosocial burden which is associated with hyperpigmentation. Nearly 45% of the participants reported that there is a negative impact on their confidence and mental health, and over 40% admitted that they have avoided social situations due to their skin appearance This is also supported by different articles showing that hyperpigmentation leads to significant emotional distress and also impaired quality of life in patients with skin color [6][20][24][25].

Over-the-counter creams and sunscreens were reported as the most commonly used products. Despite that, over 40% reported that there is little or no improvement, highlighting the potential misuse or ineffectiveness of unsupervised treatments. These findings tell the importance of accessible evidence-based dermatologic care and professional guidance, especially for the individuals with darker skin tones, in whom there is a higher risk of worsening of the condition due to incorrect treatment [18].

4.2 Pathophysiological Mechanisms

The increased prevalence and also severity of hyperpigmentation in Fitzpatrick skin types III, IV, V, and VI can be due to different structural and biochemical differences in the darker skin tones. These include differences like larger melanocytes, increased melanosome transfer and also elevated tyrosinase activity, which together increase the melanin production. In the darker pigmented skin, melanocytes not only produce more melanin but also have a higher dendritic activity, leading to a more broader dispersion of pigment into the surrounding keratinocytes [1].

The dermal-epidermal junction(DEJ) in darker skin types has a more active microenvironment. It has a greater density of fibroblasts and macrophages, particularly in the papillary dermis, which secrete a variety of signaling molecules, including monocyte chemotactic peptide-1 (MCP-1), Keratinocyte growth factor (KGF), and also matrix metalloproteases(MMPs). These molecules play an important role in melanogenesis and post-inflammatory pigment response. Which basically links the inflammation directly to pigment deposition [1][26].

Inflammation is mainly central to the development of post-inflammatory hyperpigmentation(PIH). Skin injury, which can be due to various causes like acne, cosmetic irritation, maskne, or UV exposure, leads to basal keratinocyte damage; this in turn stimulates the melanocytes to release pigment-rich melanosomes into the surrounding tissues [3][4]. In addition to this, chronic low-grade inflammation and immune activation further exacerbate the pigment formation in the skin [1].

New evidence suggests that Oxidative stress is also a key driver of hyperpigmentation. The Reactive oxygen species (ROS), which are generated during UV exposure or inflammatory responses, upregulate melanogenesis through activation of melanocyte-stimulating pathways [27]. Antioxidants such as Vitamin C, glutathione, and catalase are important in buffering this oxidative load; deficiencies or imbalances in them can worsen pigmentation [14][27].

Wnt/β-catenin and Nrf2-ARE signaling pathways have been implicated in the pigmentation regulation. They activate under oxidative stress and influence melanin synthesis, autophagy, and also cellular repair mechanisms, mainly in disorders like melasma and solar lentigines [27].

These mechanisms together explain why darker skin is more reactive to trauma and inflammation, which often result in longer-lasting and more intense pigmentation changes as observed in the current study.

4.3 Treatment Patterns, Preferences & Efficacy

The survey revealed that there is a strong reliance on over-the-counter (OTC) products, including skin-lightening creams, sunscreens, and also home remedies, particularly among Fitzpatrick types IV, V, and VI. OTC creams are the most commonly used creams for intervention, it also reflects their easy access and affordability. However, despite the widespread use, 41.6% of respondents reported no improvement, suggesting that these products may not be suitable for all forms of pigmentation, more importantly, in the absence of professional guidance.

This finding is also supported by the literature, where topical agents such as hydroquinone(HQ), kojic acid, arbutin, and retinoids are identified as first-line treatments, but their effectiveness highly depends on the concentration, and if its misused it can lead to irritation, paradoxical pigmentation, or dermatitis [18]. The literature also says that high potency treatments require careful supervision and unregulated use of HQ or combination products can have adverse outcomes like irritant dermatitis and also exogenous ochronosis [16].

Advanced therapies like chemical peels and lasers are less commonly used in this population, mainly due to the cost and access barriers. Although these therapies have been shown to be effective in treating melasma and PIH, they have a risk of complications in darker skin tones, like rebound PIH, or can even cause uneven skin lightening [18].

This survey revealed a noteworthy finding: 95% of participants indicated they would be interested in professional therapy if it could be more affordable. This explains the treatment gap mainly by economic barriers, also explains the need of low-cost, dermatologically supervised therapies.

The usage of home remedies such as turmeric, aloe vera or lemon-based preparations was also more prevalent, mainly in the south asian participants. Some plant-based treatments can be beneficial in some instances like hyperpigmentation due to uncontrolled melanogenesis because of the milder and safer effect compared to the synthetic treatments [26].

Overall, while topical agents dominate, the gap between product use and treatment success still remains wide. These findings highlight the need for better education and awareness about the treatment options, easier access to dermatologically supervised therapies, mainly for people with darker skin types, who are more likely to experience stubborn and worsening pigmentation

4.4 Sunscreen Use and Photoprotection

In the survey, 84.5% of the participants reported that they use sunscreen, which plays an important role in both the prevention and also in the treatment of hyperpigmentation, mainly in conditions like melasma and PIH, for which UV exposure is a key trigger. Articles suggest that UV and VL blocking can significantly reduce pigmentation severity [21].

4.5 Dietary & Nutritional Factors

Although it is not the primary goal of the study, the findings suggest that nutritional deficiencies contribute to hyperpigmentation, especially in the cases areas like involving knuckles, creases, and flexural areas [14]. Articles link deficiencies in Vitamin B12, B3, D, and iron to pigmentary disorders, particularly in the darker skin types [12][13][14].

4.6 Psychosocial & Emotional Impact

Hyperpigmentation, despite its physical manifestations, has an effect on the psychosocial well-being and quality of life, especially in individuals with darker skin types. In this study, 44.8% of the participants reported a negative impact on their mental health, and also 42.2% admitted that they have avoided social situations due to their condition. These findings reveal the emotional burden that hyperpigmentation can cause on the affected individual, mainly when the areas affected are the cheeks, forehead, and chin.

Hyperpigmentation, especially chronic hyperpigmentation and treatment resistance can lead to low self-confidence, social withdrawal, and heightened self-consciousness; together they contribute to psychological stress.

These findings support the need for holistic approaches in the management of hyperpigmentation, which also include mental health support and also patient education.

4.7 Underrepresented Populations in Research

The design of the study was to cover all Fitzpatrick skin types, ages, genders, and ethnic groups, yet some categories remain underrepresented. The predominant population in the study turned out to be South Asians, with the majority being Indians, favoring the preponderance of Type IV Fitzpatrick skin type in the study. Lighter skin tones [Fitzpatrick I-III] that are highly sensitive to sunlight but tan less are underrepresented. Even with low melanin content, these groups still develop hyperpigmentation around the cheeks, chin, arms, eyes, etc., possibly due to chronic sun exposure, hormonal imbalances, and skin damage. The insufficient representation of the lighter skin tones and the sun-tolerant darker skin types (Type V-VI) confined the possibility of a fair study on the prevalence and characteristics of pigmentation across all Fitzpatrick skin types. A more balanced sample would have allowed a more comprehensive and comparative understanding across the full Fitzpatrick spectrum. Therefore, future studies should try to adopt recruitment strategies that would allow extensive representation of all skin types. Moreover, female participants outnumbered the males by 12.8%. This disparity in gender distribution could have influenced the reported prevalence rates, as females are more prone to hormonal influences, use cosmetics, and seek greater care compared to their male counterparts. Participation of older adults, particularly above the age of 55, was only 0.7%. This limited the insight into age-related pigmentation disorders like mixed pattern melasma and senile lentigines.

4.8 Study Limitations

4.8.1 Methodological Limitations

Cross-sectional design makes it challenging to draw conclusions about causality. Though it's possible to find a correlation between the pigmentation patterns and risk factors, the temporal relationship cannot be established. The data was collected through an online survey without in-person physical examination of the skin by a clinician. Moreover, Fitzpatrick skin typing was based on self-report, which may have introduced misclassification bias, especially in individuals with mixed photo types. The study is subject to recall bias as it relied on self-reporting for sun exposure, use of cosmetics, hormonal influences, and the treatments availed. The study design with no follow-up limits the ability to determine whether the observed pigmentation patterns are transient, progressive, or remain stable with environmental changes, age, and treatments. Unaccounted confounding variables like undisclosed drug use, lifestyle factors, UV exposure index etc, may have resulted in residual confounding. The social and psychological effects were self-evaluated and did not utilise any validated scales like PHQ-9 or GAD-7 to assess the mental health impact of the participants, which reduces the reliability of the data.

4.8.2 Population and Sampling Limitations

The sample did not represent all Fitzpatrick skin types equally. Certain skin types were overrepresented (Type IV and V) while others were underrepresented, which biases the findings to experiences of the darker skin tones. The experiences, triggers, and response patterns of the older adults are underrepresented due to the significantly larger percentage of participants aged 18-24 (51.7%) in the study. The higher percentage of female participants (56.3%), potentially skew results in favor of conditions like melasma that are more common in women due to hormonal factors. South Asians comprised 66.2% of the sample, resulting in findings that might not apply to other ethnic groups. Underrepresented groups such as Hispanic/Latino, Middle Eastern, and Indigenous/Aboriginal made up less than 1%, suppressing the ability to make conclusions regarding those populations.

4.8.3 Diagnostic Limitations

Lesions were not biopsied or subjected to advanced diagnostic techniques. Lack of Histopathological confirmation questions the diagnostic accuracy of the report. Subtle pigmentary disorders could have been misdiagnosed or underreported. Certain skin conditions like psoriasis, eczema, etc were reported in very low numbers, making it difficult to analyse their role in hyperpigmentation.

4.8.4 Treatment Limitations

The majority of the participants relied on OTC or home remedies without proper medical supervision, which may affect the treatment outcomes and interpretations. Advanced treatment modalities like micro needling and laser therapy were availed by only a few participants, limiting the analysis of their effectiveness.

Future Research Directions

Future studies should adopt a longitudinal study design to understand the causal relation between risk factors and changes in pigmentation patterns over time. Studies focusing on the hormonal, seasonal changes, and genetic factors like the role of melanin-regulating genes and inflammatory pathways in different skin types should be detailedly assessed. Replication of the study with a more diverse range of ethnicities and geographic regions would improve the generalizability of the results. There is a paucity of information on the role of cultural and societal perceptions of skin tone and pigmentation. More Research is needed for assessing the psychological effects and self-esteem issues related to hyperpigmentation, which may inform holistic treatment approaches. Conducting randomized controlled studies, etc., would provide evidence on the efficacy , safety, and long-term outcomes of the wide variety of treatment options available.

The present study also emphasizes the need for creating awareness and enlightening the individuals on evidence-based skin care practices.

V. Conclusion

This cross-sectional study highlights the complex and multifactorial nature of hyperpigmentation, mainly among the individuals with Fitzpatrick skin types III-VI. The findings also support the important role of inflammation, genetic predisposition, hormonal changes, and also environmental exposures, most commonly UV radiation, in the pathogenesis of the pigmentary disorders. Despite the widespread use of OTC treatments (83.5%), 42% reported no improvement, pointing to the gap in professional guidance and also the need for affordable, dermatologist-guided care.

There is also the psychosocial burden reported by the participants that tells the need for accessible, effective, and affordable treatment options. Future research must mainly prioritize in understanding the causal relationship between the risk factors and changes in pigmentation over time, and also address the psychosocial impact of chronic pigmentation conditions. Improved public awareness, education, and evidence-based, skin type-specific management options are essential to advancing both the treatment outcomes and also the quality of life in the affected populations.

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