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All topics related to diseases of the skin, hair, and nails, with special emphasis on technologies for information exchange, education, and clinical care

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Assessment of Quality and Utility of Patient-Taken Smartphone Photographs of Atopic Dermatitis: Clinical Survey Study

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Abstract

Background: Atopic dermatitis (AD) has a relapsing and remitting nature, and scheduled clinic visits only provide a snapshot of the skin condition at the moment.

Objective: This study aimed to investigate the quality of patient-taken smartphone photographs of AD skin lesions and characterize patients using smartphone photographs as a tool to assist the physician to show disease activity in between consultations.

Methods: Patients from 2 university outpatient clinics specialized in AD were surveyed. A questionnaire regarding digital readiness was completed, and a previously taken skin lesion photograph on the patients' own smartphone was evaluated.

Results: Between February 2024 and September 2024, a total of 100 questionnaires were completed, 60 (60%) by participants from the capital region of Denmark and 40 (40%) by participants from an urban area, including 62 (62%) men and 38 (38%) women. The mean age of the recruited patients was 33.9 (SD 19.9) years. A total of 78% (78/100) of the patients used a desktop computer, laptop, or tablet often or always, and 86% (86/100) corresponded with the health care system using technology (eg, via email to the general practitioner or contact with hospitals via apps). More than 50% (52/100, 52%) strongly agreed or agreed with the statement that they would prefer a remote online visit with, for example, upload of skin lesion photographs over a routine in-person office visit. Almost 3 out of 4 patients had a photograph of their AD skin lesion on their smartphone, most (38/71, 54%) with the sole intention of presenting it to a physician. The photographs were of good quality in 85% (60/71) of the cases, and most (61/71, 86%) of the smartphone photographs were assessed to be useful for diagnostic and clinical evaluation. Receiving topical monotherapy was significantly associated with increased risk of having taken a skin lesion smartphone photograph (P=.006).

Conclusions: Patients with AD followed up on in an outpatient clinic often took good-quality photographs of their skin lesions before consultations with the intention of presenting them to the physician.

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KEYWORDS

atopic dermatitis; photograph; telemedicine; teledermatology; outpatient clinic; personalized; follow-up

Introduction

Atopic dermatitis (AD) has a fluctuating nature, including unpredictable flares [1], which is why scheduled visits to an outpatient clinic only provide a momentary snapshot of the disease course. Patients' perception of the use of photographs of skin lesions in clinical settings to improve medical care is overall positive [2]. A qualitative study highlighted that patients often feel unheard when consulting their physicians in times of disease remission. It also demonstrated an unfulfilled desire to be able to show a flair either by writing down symptoms or photographing lesions during flairs. Patients also indicated that the ability to evaluate the skin in between consultations provides increased autonomy and ownership [3]. A study conducted in an urticaria outpatient clinic showed that patients often took photographs of their skin lesions with their own smartphones before their first consultation, providing the physician with an insight into their disease severity at times of flare [4]. It has also been confirmed that the use of smartphones to take photographs of skin lesions is growing rapidly, a trend that might reduce the need for referrals to face-to-face visits [5] and thereby mitigate the growing shortage of dermatologists [6]. Furthermore, the severity of AD can be reliably assessed using photographs taken using smartphones as there is a high agreement between assessments conducted in the clinic directly looking at the skin and assessments conducted based on photographs [7,8].

Due to the clearly visible morphology of AD and the growing use of photographs taken using smartphones for medical

documentation purposes, we aimed to investigate the quality of patient-taken photographs of AD skin lesions using smartphones. Second, we aimed to characterize the group of patients who take smartphone photographs as a tool to assist the physician's evaluation of disease activity in between consultations. This knowledge might help understand patient preferences and tailor an individualized plan for follow-up either face-to-face or remotely based on photographs, thereby reducing health care costs while increasing patient autonomy.

Methods

Overview

Patients were consecutively recruited from 2 university outpatient clinics specialized in AD; one clinic in the capital region of Copenhagen and one from the second-largest urban area in Denmark, Aarhus. From February 2024 to September 2024, patients with a consultation in one of the outpatient clinics were asked to complete a questionnaire and select a possible previously taken smartphone photograph of their own AD lesions for severity assessment and quality evaluation by the physician. For pediatric patients, the questionnaire was completed by the parents.

To measure the perception of the impact of AD on quality of life, the Skindex-Mini, a 3-item questionnaire assessing 3 domains (symptoms, emotions, and function) graded on a Likert scale from 0 to 6, was used [9]. The Skindex-Mini total score was used to stratify impact of skin conditions on patient's quality of life as follows: a score of 0 to 1 indicated no impact, a score of 2 to 5 indicated low impact, a score of 6 to 10 indicated moderate impact, a score of 11 to 14 indicated high impact, and a score of 15 to 18 indicated very high impact on quality of life. The questionnaire has also been validated in pediatric patients with AD [10]. Questions related to use of technology in general and for communication with health care professionals were also included [11].

On the basis of the selected photograph of an AD lesion taken by the patient on their smartphone, a questionnaire regarding the quality and utility of smartphone photographs of AD skin lesions was completed by the attending physician. The quality assessment was based on focus of the photograph, resolution, lighting, and blurriness [12,13]. The utility of smartphone photographs for diagnostic use was based on the overall assessment of the treating physician (ie, whether the treating physician felt confident when using the photograph to establish diagnosis and for clinical evaluation and severity assessment). The clinical signs from the Eczema Area and Severity Index (EASI) and Scoring Atopic Dermatitis (SCORAD), including erythema, edema or papulation, excoriation, lichenification, oozing or crusts, and dryness, were assessed for each photograph along with their intensity (0-3 for the EASI and 0-4 for SCORAD) [14,15].

Statistical Analysis

Chi-square and independent-sample 2-tailed *t* tests were used to characterize patients who took smartphone photographs of skin lesions, and 95% CIs were provided when applicable. The Fisher exact test was used when one or more of the cells had an expected frequency of 5 or less. Multiple logistic regression was used to identify the variables best related to the likelihood of patients having a smartphone photograph of a skin lesion, including age (<30 years vs >30 years), sex, capital or urban area residence, AD onset (<2 years of age vs >2 years of age), quality of life (Skindex-Mini total score), systemic treatment vs topical treatment, daily use of technology, digital contact with the health care system, and whether they preferred a remote visit. A *P* value of <.05 was considered statistically significant. All tests were carried out using the SPSS software (version 25.0; IBM Corp) [16].

Ethical Considerations

As this was a questionnaire study, there was no requirement of governmental approval or written informed consent according to Danish guidelines [17]. All study participants gave oral consent to be included in the study and have their data stored. All data used in this study were fully anonymized. No personally identifiable information was collected, stored, or processed, ensuring the privacy and confidentiality of all participants. Participants did not receive any financial or nonfinancial compensation for their participation in this study.

Results

Cohort Description

A total of 100 questionnaires were completed, 60 (60%) by participants from the capital region and 40 (40%) by participants from the urban area, including 62 (62%) men and 38 (38%) women. The median age of the recruited patients was 28.0 (IQR 20.25-48.75; mean age 33.9, SD 19.9) years. Most (n=53, 53%) had an AD onset before the age of 2 years, 25% (n=25) had an AD onset between the ages of 2 and 6 years, 10% (n=10) had an AD onset between the ages of 6 and 18 years, and the remaining 12% (n=12) had an AD onset after the age of 18 years. A total of 37% (n=37) of the patients were treated with topical corticosteroids in monotherapy at the time of consultation, 36% (n=36) were treated with dupilumab, 12% (n=12) were treated with methotrexate, 3% (n=3) were treated with tralokinumab, and 3% (n=3) were treated with baricitinib or abrocitinib. Most patients (n=64, 64%) estimated AD to have none or a small impact on quality of life, 19% (n=19) estimated AD to have a moderate impact, 10% (n=10) estimated AD to have a large impact, and 7% (n=7) estimated AD to have a very large impact based on the Skindex-Mini questionnaire (Table 1).

Table . Characteristics of the included patients from 2 atopic dermatitis outpatient clinics (N=100).

Characteristic	Values
Sex, n (%)	
Male	62 (62)
Female	38 (38)
Age (years), mean (SD)	33.9 (19.9)
Current treatment, n (%)	
Topical treatment[a] only	38 (38)
UVB	1 (1)
Traditional immunosuppressants[b]	16 (16)
Prednisolone	1 (1)
JAK[c] inhibitors	3 (3)
Biologics[d]	39 (39)
None	2 (2)
Skindex-Mini score (0-18), mean (SD)	
Symptoms	2.25 (1.88)
Emotions	1.51 (1.81)
Function	1.30 (1.77)
Total	5.02 (5.03)
Impact on quality of life, n (%)	
None	33 (33)
Small	31 (31)
Moderate	19 (19)
Large	10 (10)
Very large	7 (7)

[a]Topical corticosteroids and topical calcineurin inhibitors.

[b]Azathioprine, methotrexate, and mycophenolate mofetil.

[c]JAK: Janus kinase; inhibitors included abrocitinib and baricitinib.

[d]Dupilumab and tralokinumab.

Digital Readiness

In total, 78% (78/100) of the patients used a computer, laptop, or tablet often or always; 18% (18/100) used them seldom or once in a while; and 4% (4/100) never used them. A vast majority (86/100, 86%) corresponded with the health care system using technology (eg, via email to the general practitioner or contact with hospitals via apps). More than 50% (52/100, 52%) strongly agreed or agreed with the statement that they would prefer a remote online visit with, for example, upload of skin lesion photographs over a routine in-person office visit. Table 2 provides further details.

Table . Items related to attitudes toward digital solutions (N=100).

Digital readiness	Participants, n (%)
Daily use of a computer, laptop, or tablet	
Often or always	78 (78)
Seldom or once in a while	18 (18)
Never	4 (4)
Digital correspondence with the health care system	
Often or always	56 (56)
Seldom or once in a while	30 (30)
Never	14 (14)
Digital access to blood samples or medical records	
Often or always	53 (53)
Seldom or once in a while	34 (34)
Never	13 (13)
Search for information related to morbidity on the internet	
Often or always	42 (42)
Seldom or once in a while	35 (35)
Never	23 (23)
"I would like to replace a physical in-office visit with a remote visit."	
Strongly agree	19 (19)
Agree	33 (33)
Neutral	27 (27)
Disagree	12 (12)
Strongly disagree	9 (9)

Smartphone Photographs

Almost 3 out of 4 patients (71/100, 71%) had a photograph of their AD skin lesion on their smartphone. Of the remaining 29% (29/100) who did not have any photographs of their AD lesions on their smartphones, most (15/29, 52%) indicated that the reason was a well-controlled disease for a longer period without experiencing any flair or worsening of AD, only 3% (1/29) did not have a smartphone, 7% (2/29) used another smartphone to take photographs, and the remaining 38% (11/29) did not give a reason. The number of smartphone photographs of AD lesions taken in the previous year varied from 1 to 100, the mean number of photographs taken was 21.4 (SD 22.7), and the median number of photographs was 15 (IQR 5-25). Most of those who took photographs did so with the sole intention of presenting them to a physician (38/71, 54%), only 8% (6/71) took the photographs for their own use, and 38% (27/71) took the photographs both for their own use and for the physician. Most of the photographs were of upper limbs (26/71, 37%) or the head and neck (23/71, 32%). Of all evaluated photographs, 85% (60/71) were of good quality, 7% (5/71) were of acceptable quality, and 9% (6/71) were of bad quality based on lighting, resolution, clarity, and focus. In total, 89% (63/71) of the smartphone photographs had the skin lesion in focus, of which 92% (65/71) were sharp and 9% (6/71) were blurred. Most of the smartphone photographs (61/71, 86%) were assessed to be useful for diagnostic and clinical evaluation (Table 3).

Table . Smartphone photographs taken by the patients coming to consultation in outpatient clinics (n=71).

	Photographs, n (%)
Body region	
Head and neck	23 (32)
Chest and stomach	6 (8)
Back	11 (15)
Upper limb	26 (37)
Lower limb	4 (6)
Missing	1 (1)
Lesion in focus	
Agree	63 (89)
Disagree	8 (11)
Sharp photograph	
Agree	65 (92)
Disagree	6 (9)
Useful in diagnostic evaluation	
Agree	61 (86)
Disagree	10 (14)
Useful in severity assessment	
Agree	59 (83)
Disagree	12 (17)
Resolution	
Good	63 (89)
Acceptable	8 (11)
Bad	0 (0)
Lighting	
Good	61 (86)
Acceptable	4 (6)
Bad	6 (8)
Photo quality	
Good	60 (85)
Acceptable	5 (7)
Bad	6 (8)

For EASI items, induration (14/71, 20%) and lichenification (10/71, 14%) were often difficult to assess (Table 4), and for SCORAD items, lichenification (11/71, 16%) and dryness (13/71, 18%) proved the biggest challenge (Table 5).

Table . Severity assessment of atopic dermatitis lesion photographs based on Eczema Area and Severity Index (EASI) (n=71).

	EASI score, n (%)				
	None	Mild	Moderate	Severe	Difficult to assess
Erythema	1 (1)	20 (28)	24 (34)	22 (31)	4 (6)
Induration	16 (23)	13 (18)	21 (30)	7 (10)	14 (20)
Excoriation	27 (38)	16 (23)	13 (18)	9 (13)	6 (8)
Lichenification	26 (37)	20 (28)	7 (10)	8 (11)	10 (14)

Table . Severity assessment of atopic dermatitis lesion photographs based on Scoring Atopic Dermatitis (SCORAD) tool (n=71).

	SCORAD score, n (%)					
	None	Mild	Moderate	Severe	Very severe	Difficult to assess
Erythema	2 (3)	19 (27)	20 (28)	14 (20)	12 (17)	4 (6)
Edema	19 (27)	16 (23)	12 (17)	9 (13)	7 (10)	8 (11)
Oozing	41 (58)	15 (21)	6 (9)	2 (3)	1 (1)	6 (9)
Excoriation	31 (44)	12 (17)	12 (17)	8 (11)	2 (3)	6 (9)
Lichenification	28 (39)	12 (17)	7 (10)	10 (14)	3 (4)	11 (16)
Dryness	15 (21)	19 (27)	11 (16)	9 (13)	4 (6)	13 (18)

Characteristics of Patients Who Took Smartphone Photographs of Skin Lesions

We found a significant difference in mean age between patients who took photographs and those who did not of 16.3 years (95% CI 8.15-24.46; *P*<.001). The mean age of patients who took smartphone photographs was 29.2 (SD 18.9) years, and that of patients who did not take smartphone photographs was 45.5 (SD 17.8) years. Previous digital contact with the health care system was associated with an increased odds ratio (OR) of 7.19 (95% CI 1.31-39.51; *P*=.01) of taking a skin lesion smartphone photograph. Patients receiving topical monotherapy had a higher chance of taking a skin lesion photograph (OR 4.17, 95% CI 1.42-12.16; *P*=.006), and patients receiving systemic treatment had a lower risk of taking a skin lesion photograph (OR 0.20, 95% CI 0.07-0.59; *P*=.002; Table 6). In logistic regression analysis, use of topical treatment was a statistically significant predictor for the probability of taking a photograph of a skin lesion (OR 5.67, 95% CI 1.20-26.77; β=1.74; SE 0.79; *P*=.03).

Table . Comparison between patients who took at least 1 smartphone photograph of their skin lesions and those who did not.

Characteristic	Photograph (n=71), n (%)	No photograph (n=29), n (%)	OR[a] (95% CI)	*P* value
Sex			1.24 (0.50 - 3.05)	.64
Male	43 (61)	19 (66)		
Female	28 (39)	10 (34)		
Age (years)			0.18 (0.07-0.49)	<.001
<30	45 (63)	7 (24)		
>30	26 (37)	22 (76)		
Residence			2.03 (0.79-5.21)	.14
Capital region	40 (56)	21 (72)		
Urban area	31 (44)	8 (28)		
Age at disease onset (years)			1.08 (0.45-2.55)	.87
<2	38 (54)	15 (52)		
>2	33 (46)	14 (48)		
Topical treatment only			4.17 (1.42-12.16)	.006
Yes	33 (46)	5 (17)		
No	38 (54)	24 (83)		
Traditional immunosuppressants			0.88 (0.28-2.80)	.83
Yes	11 (15)	5 (17)		
No	60 (85)	24 (83)		
Systemic treatment[b]			0.20 (0.07-0.59)	.002
Yes	35 (49)	24 (83)		
No	36 (51)	5 (17)		
Biologics or JAK[c] inhibitors			0.25 (0.10-0.63)	.002
Yes	23 (32)	19 (66)		
No	48 (68)	10 (34)		
Preferred remote visit[d]			1.23 (0.42-3.66)	.71
Yes	37 (52)	15 (52)		
No	14 (20)	7 (24)		
Daily use of technology			8.07 (0.80-81.17)	.07
Yes	70 (99)	26 (90)		
No	1 (1)	3 (10)		
Digital contact with the health care system[e]			7.19 (1.31-39.51)	.01
Yes	69 (97)	24 (83)		
No	2 (3)	5 (17)		
Impact of disease on quality of life			0.64 (0.42-0.97)	.04
None	17 (24)	16 (55)		
Small	26 (37)	5 (17)		
Moderate	15 (21)	4 (14)		
Large	6 (8)	4 (14)		
Very large	7 (10)	0 (0)		

[a]OR: odds ratio.

[b]Systemic treatment included dupilumab, tralokinumab, baricitinib, abrocitinib, methotrexate, azathioprine, and mycophenolate mofetil.

[c]JAK: Janus kinase.

[d]Includes “strongly agree” or “agree” vs “strongly disagree” or “disagree.”

[e]Includes both digital correspondence with the health care system and digital access to blood samples or medical records.

Discussion

Hospital outpatients with AD had high digital readiness, with 78% (78/100) using a computer, laptop, or tablet often or always. Almost 3 out of 4 had taken a photograph of their AD skin lesion on their smartphone, mostly with the intention of presenting it to a physician. Furthermore, 85% (60/71) of the photographs were of good quality; however, induration, lichenification, and dryness were often difficult to assess. Receiving topical monotherapy was associated with a higher chance of taking a skin lesion photograph, supporting the demand for tailored monitoring depending on patients’ preferences and risk of flair. AD is very heterogeneous in terms of symptoms, skin manifestations, body area involved, extent, course, and comorbidities. Therefore, it is very unlikely that all patients with AD will respond equally well to treatments. Biomarkers will lead to better identification of patients who will benefit from immunomodulatory treatments, leading to more individualized management [18]. Traditionally, patients on immunosuppressive drugs have often planned consultations in the clinic at certain intervals. Due to better disease control with targeted therapies, these patients only need to be followed up on, for example, once every year; however, due to the expenses related to the treatments, close monitoring will be beneficial for timely drug dose tapering to reduce unnecessary health care expenditures. On the other hand, many patients with mild to moderate disease will still be on traditional immunosuppressive drugs, not meeting the criteria for expensive biological treatments. These patients will often experience flairs in between scheduled consultations. Our study showed that more than half of patients with AD followed up on in an outpatient clinic preferred a remote or online visit instead of an in-person visit at the clinic. Furthermore, there is increasing evidence that patients with skin diseases often take good-quality photographs of their skin lesions with their smartphones [4] and that photographs have high validity and reliability [7,8,19]. This is supported by our findings. Tailored monitoring considering the age, digital readiness, type of treatment, and preferences of the patients may lead to a reduction in health care costs and help pivot consultations toward focused care based on individual needs.

Smartphones are easily accessible and extensively used to take photographs. Many photographs are taken on a daily basis, and more than 90% of all photographs are taken in 2020 using smartphones [20]. Many people find it natural to take photographs for memory or documentation [20]; hence, taking photographs of skin lesions is widely practiced [4]. There is a demand for integrating smartphone photographs into clinical practice to assess disease fluctuation in between physical examinations. Educating patients in how to take a good clinical photograph of AD skin lesions may improve the quality and utility of the photographs in a clinical setting. Information regarding distance between the camera and the skin lesion (approximately 20 cm), using a uniform background, and taking the photograph in good natural lighting is especially important. Furthermore, using photographs in a clinical setting through a remote visit to replace a physical consultation requires thorough patient education in the assessment of body surface area and selection of representative lesions in each anatomical area included in the EASI or SCORAD.

Even though the task of evaluating the quality of photographs was clearly defined to create consistency in evaluations, this study was limited by a lack of multiple raters to evaluate the same photograph due to logistical challenges in a clinical survey.

In conclusion, patients with AD followed up on in an outpatient clinic often took high-quality photographs of their skin lesions before consultations with the intention of presenting them to the physicians. More evidence for tailored or personalized monitoring through remote visits using photographs of skin lesions and its effect on health care costs is warranted.

Conflicts of Interest

CV has received grants from Pfizer, LEO Pharma, Almirall, and Sanofi and has been a speaker or served on advisory boards for Pfizer, Almirall, LEO Pharma, AbbVie, Sanofi, Galderma, Pierre Fabre, AstraZeneca, and Novartis. All other authors declare no other conflicts of interest.

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Abbreviations

AD: atopic dermatitis
EASI: Eczema Area and Severity Index
OR: odds ratio
SCORAD: Scoring Atopic Dermatitis

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Association of Skin Cancer With Clinical Depression and Poor Mental Health Days: Cross-Sectional Analysis

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Abstract

Background: Mental health is becoming increasingly recognized as an important part of overall health, especially for patients with cancer. However, the relationship between nonmelanoma skin cancer and mental health has not been widely studied.

Objective: The aim of this study was to examine the association between nonmelanoma skin cancer diagnosis and 2 key mental health outcomes (ie, clinical depression and the number of poor mental health days).

Methods: This study used the 2023 Behavioral Risk Factor Surveillance System, a nationally representative survey of adults in the United States, which included 312,317 participants. Nonmelanoma skin cancer diagnosis, depression, and self-reported mental health days were analyzed. Logistic regression was used to evaluate the association between nonmelanoma skin cancer and depression, whereas Poisson regression was used to model the number of poor mental health days, adjusting for age, sex, race and ethnicity, education, BMI, income, and major comorbid conditions (other cancers, heart disease, lung disease, and kidney disease).

Results: Individuals with nonmelanoma skin cancer (5086/26,552, 19.15%) reported a lower overall rate of depression compared to those without nonmelanoma skin cancer (61,438/285,765, 21.50%; *P*<.001) but reported more poor mental health days on average (4.54, SD 8.37 d vs 3.20, SD 7.37 d; *P*<.001). After adjustment, nonmelanoma skin cancer diagnosis was not significantly associated with depression (adjusted odds ratio 1.01, 95% CI 0.98 - 1.05) and was associated with a slightly lower number of poor mental health days (adjusted rate ratio 0.94, 95% CI 0.91 - 0.97).

Conclusions: Adults with nonmelanoma skin cancer experienced a meaningful mental health burden, and unadjusted analyses suggested greater day-to-day distress than among adults without nonmelanoma skin cancer. However, these differences were reduced and no longer significant for depression after adjusting for sociodemographic factors and comorbid chronic illnesses. These findings support the need for mental health screenings and support services in dermatologic and oncologic care.

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KEYWORDS

mental health; nonmelanoma skin cancer; depression; sociodemographic variables; analysis

Introduction

Background

In recent years, public health conversations have continued to emphasize the importance of mental health. Mental health is increasingly viewed not as a stand-alone issue, but as a factor that deeply interacts with physical illness, such as cancer [1].

While nonmelanoma skin cancer has obvious physical consequences, it poses serious complications regarding mental health. This aspect has not received sufficient attention in the health care field [2]. Dermatologists and oncologists are facing a dramatic rise in cases of nonmelanoma skin cancer, with melanoma rates doubling over the past two decades [3]. Nonmelanoma skin cancer is one of the most diagnosed malignancies in the world today, with rates for both melanoma and nonmelanoma types on the rise [3]. The relationship between mental state and nonmelanoma skin cancer is a complex feat. While the stress of diagnosis and treatment can create or worsen mental health conditions [4,5], existing mental health conditions can also increase the chances of developing nonmelanoma skin cancer through behavioral, immunological, and systemic mechanisms [6]. Recent evidence shows that approximately 30% of patients with melanoma experience anxiety, and nearly 20% experience depression. The highest risk has been observed among women and young adults [7]. Other studies have confirmed similar trends, showing that psychological distress and the fear of recurrence remain substantial even in patients with early-stage melanoma.

Research conducted recently has started to uncover the complex relationships between mental health and nonmelanoma skin cancer. A 2016 cross-sectional study using Behavioral Risk Factor Surveillance System data found that individuals who had frequent poor mental health days had a significantly higher chance of being diagnosed with the disease of nonmelanoma skin cancer [8].

These data were confirmed even after using the multivariate logistic regression analyses. These analyses suggest a possible link between poor mental health and keratinocyte carcinoma. This could be possible through factors such as dysregulated immune responses [9]. Other studies have shown similar results, mostly highlighting a high dose of psychological distress among patients with cancer [5,8]. Additionally, approximately one-third of patients with melanoma skin cancer require professional mental health care but are not receiving that treatment [1,2].

Further literature reviews on neuroendocrine-immune interactions support the biological plausibility of this connection. Chronic mental distress is a well-known contributor to the disruption of skin immunity, wound healing, and active inflammatory mediators, which can all contribute to the progression of cancer [6]. Additionally, factors including hostility and depression have been connected to melanoma and its treatment outcomes [4]. There is an extremely minimal amount of information regarding the demographic or socioeconomic factors that shape the outcomes of mental health across nonmelanoma skin cancer subtypes [3,10].

This study aimed to address these gaps in knowledge by analyzing the association between mental health disorders and the rate of nonmelanoma skin cancer diagnosis by using the information provided by the Behavioral Risk Factor Surveillance System (BRFSS). Focusing on nonmelanoma skin cancers, assessing the link between nonmelanoma skin cancer and mental health status by sociodemographic factors, such as age, sex, race, income, BMI, and education, will provide critical insights into how mental health influences the risk and experience of nonmelanoma skin cancer.

Literature Review

Recent studies document consistent associations between multiple indicators of psychological distress and nonmelanoma skin cancer. A proportional meta-analysis of patients with melanoma reported prevalence estimates of 30% for anxiety and 20% for depression, with higher odds observed among women, younger adults, and individuals with lower education levels [7]. Similar findings have been reported in earlier clinical and observational studies, showing elevated levels of psychological symptoms across different stages of melanoma, including treatment and posttreatment phases [5,11].

Beyond symptom prevalence, multiple studies have examined behavioral and biological pathways linking mental health to nonmelanoma skin cancer. Young adults with mental health problems demonstrate higher rates of cancer-related risk behaviors, such as smoking, alcohol use, sleep disturbances, and inactivity, which may contribute to disease development or worse outcomes [10]. Experimental research has also shown that chronic psychological stress alters neuroendocrine and immune signaling, increasing inflammatory activity and harming skin repair processes [6]. Additional studies have reported relationships between melanoma severity and personality traits, such as hostility and depressive tendencies.

More recent research has shifted attention to survivorship and early-stage disease. Patients diagnosed with melanoma have reported reduced emotional well-being. They have also stated persistent uncertainty despite a favorable clinical prognosis. This suggests that psychological effects extend further than cancer itself. Moreover, fear of recurrence has been identified as a primary contributor to ongoing mental distress following the completion of treatment [12]. These findings indicate that mental health challenges in nonmelanoma skin cancer populations can include forms of distress that may not be clinically diagnosed.

Population-based research has identified variation in mental health outcomes among patients with nonmelanoma skin cancer across demographic and socioeconomic subgroups. Studies have shown that mental health service use remains limited, with unmet psychological needs concentrated among older adults and lower-income populations [1,2]. Global assessments have revealed a lower quality of life in regions with lower access to supportive care resources [3].

Globally, the burden of skin disease is high in many regions, especially Asia, and is linked to socioeconomic status and inflammatory conditions [3]. Tools such as the Skin Cancer Index have been developed to measure the quality of life in patients with nonmelanoma skin cancer [13].

Methods

Participants

This study used data from the BRFSS, a nationally representative survey conducted by the Centers for Disease Control and Prevention [9]. The data used were from the year 2023. The BRFSS surveys US adults aged 18 years or older, collecting data on health conditions, behaviors, and preventive health practices [9]. This dataset included responses to questions related to nonmelanoma skin cancer, mental health, and sociodemographic characteristics. Participants with missing, refused, or “don’t know” responses were excluded from the analyses to ensure the high quality and reliability of the study.

Exposure

The independent variable was a self-reported diagnosis of nonmelanoma skin cancer. These individuals did not have to have a current diagnosis; the diagnosis could be from any time in the past. Respondents were asked whether a health professional had ever told them they had skin cancer, including melanoma and nonmelanoma types. Individuals who answered “yes” were categorized as having a nonmelanoma skin cancer diagnosis. Those who answered “no” were the comparison group. Those with missing or ambiguous responses were excluded from the analysis to maintain the integrity of the data.

Outcomes

The 2 primary mental health–related outcomes that were examined were depression and the number of poor mental health

days an individual had. Depression was defined as being diagnosed with a depressive disorder by a health care professional [9,10]. Poor mental health days were based on the number of days during the past 30 days that an individual reported that their mental health was "not good," including stress, depression, and other emotional issues [1,3]. Respondents with invalid responses were excluded from the analysis.

Covariates

The sociodemographic variables that were included in the analysis were age (18 - 64 and ≥65 years), sex (male or female), race or ethnicity (White only, Black only, Asian only, American Indian or Alaskan Native only, Native Hawaiian or other Pacific Islander only, multiracial, and other), education (did not graduate high school, graduated high school, attended college or technical school, and graduated from college or technical school), and BMI (underweight, normal weight, overweight, and obese). Additional health-related covariates included self-reported diagnoses of other (non–skin) cancer, heart disease, chronic lung disease, and kidney disease. These covariates were specifically selected based on the evidence linking them to mental health and cancer-related outcomes [3,10].

Statistical Analysis

Descriptive statistics were first used to summarize the distribution of depression status and the number of poor mental health days by nonmelanoma skin cancer diagnosis and sociodemographic variables, including age, sex, race and ethnicity, education level, and BMI. All statistical models were run on the entire BRFSS sample, and individuals without a history of nonmelanoma skin cancer served as the reference group. This allowed a direct comparison between those with and those without nonmelanoma skin cancer. Categorical variables were summarized using frequencies and percentages, while continuous variables were described using means and SDs. Group differences in categorical variables were assessed using Pearson χ^2 tests, and differences in continuous outcomes were interpreted using independent samples *t* tests. These tests described unadjusted differences between adults with and without a history of nonmelanoma skin cancer.

To examine the association between nonmelanoma skin cancer diagnosis and depression, a multivariable logistic regression model was used [9]. Depression was treated as a yes or no outcome, and a nonmelanoma skin cancer diagnosis (yes or no) was the main comparison of interest. All statistical models were run on the full BRFSS sample, and individuals without a history of nonmelanoma skin cancer served as the reference group in all analyses. This approach allowed direct comparison of depression prevalence and poor mental health days between respondents with and without nonmelanoma skin cancer, instead of limited analyses to only the skin cancer subgroup. Additionally, adjusted odds ratios (aORs) and corresponding 95% CIs were reported.

For the continuous outcome of mental health days, a multivariable Poisson regression model with standard errors to account for potential overdispersion was used. The results were expressed as adjusted rate ratios (aRRs) with 95% CIs, which allowed for the calculation of the relative increase or decrease in the expected number of poor mental health days among individuals with nonmelanoma skin cancer compared to those without, after accounting for sociodemographic factors. Both regression models adjusted for age, sex, race and ethnicity, education level, BMI, household income, and comorbid conditions (other cancer, heart disease, lung disease, and kidney disease). These sociodemographic and health-related variables are independently associated with both mental health outcomes and cancer risk in prior studies. Logistic regression was used for the binary depression outcome, whereas a multivariable Poisson regression model was used for the count-based outcome of poor mental health days. Poisson regression was selected because the outcome represents a count of days within a fixed 30-day period and was not normally distributed, making linear regression inappropriate. Standard errors were adjusted to account for overdispersion. The distribution of days with poor mental health was examined. It was discovered that, although the data showed variability, it did not exhibit sufficient overdispersion to warrant switching to an alternative model. Therefore, the Poisson model was the best option.

All statistical tests were 2 sided. Analyses were conducted using JASP, ensuring appropriate complex survey weighting to reflect the nationally representative design of the BRFSS dataset [9].

Ethical Considerations

This study involved secondary analysis of publicly available, deidentified data from the BRFSS, administered by the US Centers for Disease Control and Prevention. As the dataset contains no identifiable private information, this study did not constitute human subjects research and was therefore exempt from institutional review board review in accordance with US federal regulations. The BRFSS protocol is reviewed and approved annually by the US Centers for Disease Control and Prevention Institutional Review Board, and informed consent is obtained from all participants at the time of data collection.

Results

Overview

Among 433,323 participants in the 2023 BRFSS questionnaire, 312,317 (72.07%) had complete demographic and disease information and were included in the analysis (Table 1). Among the analytical cohort, 154,230 (49.38%) were men, and 158,087 (50.62%) were women. Additionally, 253,634 (81.21%) identified as White participants only. The remaining racial and ethnic distribution included 26,936 (8.62%) Asian only, 6551 (2.10%) Black only, 8865 (2.84%) American Indian or Alaska Native only, 2041 (0.65%) Native Hawaiian or Pacific Islander, 5742 (1.84%) multiracial, and 8548 (2.74%) identifying as other race and ethnicity.

Table . Characteristics of the study cohort [8].

Characteristics	Values
Skin cancer diagnosis, n (%)	
No	285,765 (91.50)
Yes	26,552 (8.50)
Depression, n (%)	
No	245,793 (78.70)
Yes	66,524 (21.30)
Mental health days, mean (SD)	4.42 (8.29)
Race and ethnicity, n (%)	
White only	253,634 (81.21)
Asian only	26,936 (8.62)
Black only	6551 (2.10)
American Indian or Alaskan Native only	8865 (2.84)
Native Hawaiian or other Pacific Islander only	2041 (0.65)
Multiracial	5742 (1.84)
Other race only	8548 (2.74)
Sex, n (%)	
Male	154,230 (49.38)
Female	158,087 (50.62)
Age (y), n (%)	
18-64	198,394 (63.52)
≥65	113,923 (36.48)
BMI, n (%)	
Underweight	4802 (1.54)
Normal weight	89,431 (28.63)
Overweight	111,680 (35.76)
Obese	106,404 (34.07)
Education, n (%)	
Did not graduate high school	14,184 (4.54)
Graduated high school	73,285 (23.46)
Attended college or technical school	83,761 (26.82)
Graduated from college or technical	141,087 (45.17)
Other cancer, n (%)	
No	275,645 (88.26)
Yes	36,672 (11.74)
Heart disease, n (%)	
No	277,856 (88.97)
Yes	34,461 (11.03)
Lung disease, n (%)	
No	251,263 (80.45)
Yes	61,054 (19.55)
Kidney disease, n (%)	
No	297,584 (95.28)

Characteristics	Values
Yes	14,733 (4.72)

Most of the 312,317 respondents were aged between 18 and 64 years (n=198,394, 63.52%), with 113,923 (36.48%) aged 65 years or older. BMI classifications showed that 4802 (1.54%) were underweight, 89,431 (28.63%) had a normal BMI, 111,680 (35.76%) were overweight, and 106,404 (34.07%) were obese. Educational attainment also varied, with 14,184 (4.54%) not graduating from high school, 73,285 (23.46%) graduating from high school, 83,761 (26.82%) attending some college or technical school, and 141,087 (45.17%) graduating from a college or technical program.

Most respondents did not report a nonmelanoma skin cancer diagnosis, with 285,765 (91.50%) of 312,317 indicating no history of nonmelanoma skin cancer and 26,552 (8.50%) reporting a diagnosis. Additionally, 245,793 (78.70%) participants did not report depression, whereas 66,524 (21.30%) reported having been diagnosed with depression by a health care professional. The high average number of mental health days was consistent with high fluctuations in mental health experiences across many individuals.

Comorbid health conditions were also reported. A total of 36,672 (11.74%) participants reported another form of cancer, 34,461 (11.03%) reported heart disease, 61,054 (19.55%) reported lung disease, and 14,733 (4.72%) reported kidney disease.

The average number of poor mental health days in the past 30 days was 4.42 (SD 8.29). This was consistent with substantial variation in mental health experiences across the population.

Depression

Of the entire sample, 88,524 (21.31%) of 312,317 participants reported experiencing depression. Of those without a nonmelanoma skin cancer diagnosis, 61,428 (21.50%) of 285,765 reported depression. However, of those with a nonmelanoma skin cancer diagnosis, 5086 (19.15%) of 26,552 individuals reported depression. After the analysis was adjusted for the included covariates, nonmelanoma skin cancer diagnosis was not significantly associated with depression (aOR 1.01, 95% CI 0.98 - 1.05; P<.001; Table 2).

Table . Association between nonmelanoma skin cancer and depression [8].

Characteristics	Depression			
	No, n (%)	Yes, n (%)	*P* value	aOR[a] (95% CI)
Nonmelanoma skin cancer diagnosis			<.001	
No	224,327 (78.5)	61,438 (21.4)	<.001	Ref[b]
Yes	21,466 (80.8)	5086 (19.1)	<.001	1.01 (0.98 - 1.05)
Race and ethnicity			<.001	
White only	1,97,650 (77.9)	55,984 (22)	<.001	Ref
Asian only	22,476 (83.4)	4460 (16.5)	<.001	0.50 (0.48 - 0.52)
Black only	5135 (78.3)	1416 (21.6)	<.001	0.70 (0.66 - 0.75)
American Indian or Alaskan Native only	7863 (88.6%)	1002 (11.3%)	<.001	0.47 (0.440.50)
Native Hawaiian or other Pacific Islander only	1721 (84.3)	320 (15.6)	<.001	0.51 (0.45 - 0.58)
Multiracial	4778 (83.2)	964 (16.7)	<.001	0.60 (0.56 - 0.64)
Other race only	6170 (72.1)	2378 (27.8)	<.001	1.08 (1.04 - 1.15)
Sex			<.001	
Male	130,827 (84.8)	23,403 (15.1)	<.001	Ref
Female	114,966 (72.7)	43,121 (27.2)	<.001	1.98 (1.94 - 2.02)
Age (years)			<.001	
18-64	150,115 (75.6)	48,279 (24.3)	<.001	Ref
≥65	95,678 (83.9)	18,245 (16)	<.001	0.44 (0.440.45)
BMI			<.001	
Underweight	3581 (74.5)	1221 (25.4)	<.001	Ref
Normal weight	72,440 (81)	16,991 (18.9)	<.001	0.83 (0.77 - 0.89)
Overweight	91,376 (81.8)	20,304 (18.1)	<.001	0.87 (0.81 - 0.94)
Obese	78,396 (73.6)	28,008 (26.3)	<.001	1.18 (1.10 - 1.27)
Education			<.001	
Did not graduate high school	10,816 (76.2)	3368 (23.7)	<.001	Ref
Graduated high school	58,033 (79.1)	15,252 (20.8)	.27	0.98 (0.94 - 1.02)
Attended college or technical school	63,782 (76.1)	19,979 (23.8)	<.001	1.02 (0.98 - 1.07)
Graduated from college or technical	113,162 (80.2)	27,925 (19.7)	<.001	0.91 (0.87 - 0.95)
Other cancer			<.001	1.12 (1.08 - 1.15)
No	217,198 (78.7)	58,447 (21.2)	<.001	Ref
Yes	28,595 (77.9)	8077 (22)	<.001	1.12 (1.08 - 1.15)
Heart disease			<.001	
No	220,365 (79.3)	57,491 (20.6)	<.001	Ref
Yes	25,428 (73.7)	9033 (26.2)	<.001	1.41 (1.37 - 1.45)
Lung disease			<.001	
No	206,137 (82)	45,126 (17.9)	<.001	Ref
Yes	39,656 (64.9)	21,398 (35)	<.001	2.10 (2.05 - 2.14)
Kidney disease			<.001	

Characteristics	Depression			
	No, n (%)	Yes, n (%)	*P* value	aOR[a] (95% CI)
No	235,503 (79.1)	62,081 (20.8)	<.001	Ref
Yes	10,290 (69.8)	4443 (30.1)	<.001	1.47 (1.41 - 1.53)

[a]aOR: adjusted odds ratio.

[b]Ref: reference.

When analyzing all racial and ethnic groups, there were many considerable differences in the prevalence of depression. White respondents were used as the reference group. Using the reference group, Asian (aOR 0.50, 95% CI 0.48 - 0.52), Black (aOR 0.70, 95% CI 0.66 - 0.75), American Indian or Alaska Native (aOR 0.47, 95% CI 0.44 - 0.50), Native Hawaiian or other Pacific Islander (aOR 0.51, 95% CI 0.45 - 0.58), and multiracial respondents (aOR 0.60, 95% CI 0.56 - 0.64) all had lower adjusted odds of depression. Participants in the "other" category had slightly higher odds of depression compared to White respondents (aOR 1.08, 95% CI 1.04 - 1.15).

Women (43,121/158,087, 27.28%) reported significantly higher rates of depression compared to men (23,403/154,230, 15.19%). After adjustment, women had almost double the odds of depression when compared to men (aOR 1.98, 95% CI 1.94 - 2.02). Participants (18,245/113,923, 16.0%) aged 65 years or older had significantly lower rates of depression compared to adults (48,279/198,394, 24.3%) aged 18 to 64 years. BMI also played a substantial role. With underweight individuals as the reference group, obese individuals experienced higher odds of depression (aOR 1.18, 95% CI 1.10 - 1.27), while those who were underweight or of normal weight had lower odds compared to those who were considered overweight or obese.

After adjusting for covariates, high school graduates had similar odds of depression to the reference group (aOR 0.98, 95% CI 0.94 - 1.02). Participants who had reached the college level of education had slightly different odds (aOR 1.02, 95% CI 0.98 - 1.07), and college graduates had lower odds (aOR 0.91, 95% CI 0.87 - 0.95).

Poor Mental Health Days

Respondents with a history of nonmelanoma skin cancer reported a higher average number of poor mental health days (mean 4.54, SD 8.37) compared to those without a nonmelanoma skin cancer diagnosis (mean 3.20, SD 7.37). However, after adjustment, individuals with nonmelanoma skin cancer experienced a slight decrease in poor mental health days compared to those without (aRR 0.94, 95% CI 0.91 - 0.97; Table 3).

Table . Association between nonmelanoma skin cancer and poor mental health days [8].

Characteristics	Mental health days		
	Mean (SD)	*P* value	aRR[a] (95% CI)
Skin cancer diagnosis		<.001	
No	3.19 (7.36)	<.001	Ref[b]
Yes	4.54 (8.36)	<.001	0.94 (0.91 - 0.97)
Race and ethnicity		<.001	
White only	4.30 (8.17)	<.001	Ref
Asian only	4.80 (8.65)	<.001	0.93 (0.90 - 0.95)
Black only	5.86 (9.52)	<.001	1.07 (1.01 - 1.13)
American Indian or Alaskan Native only	3.36 (6.85)	<.001	0.82 (0.78 - 0.86)
Native Hawaiian or other Pacific Islander only	5.42 (9.34)	<.001	1.11 (1.00 - 1.24)
Multiracial	4.65 (8.70)	<.001	0.93 (0.88 - 1.00)
Other race only	6.45 (9.74)	<.001	1.25 (1.19 - 1.32)
Sex		<.001	
Male	3.64 (7.71)	<.001	Ref
Female	5.18 (8.74)	<.001	1.36 (1.34 - 1.39)
Age (y)		<.001	
18-64	5.43 (8.85)	<.001	Ref
≥65	2.66 (6.85)	<.001	0.40 (0.40 - 0.41)
BMI		<.001	
Underweight	6.37 (9.81)	<.001	Ref
Normal weight	4.18 (7.95)	<.001	0.76 (0.71 - 0.82)
Overweight	3.78 (7.70)	<.001	0.71 (0.67 - 0.76)
Obese	5.20 (8.98)	<.001	0.83 (0.78 - 0.89)
Education		<.001	
Did not graduate high school	6.13 (10.21)	<.001	Ref
Graduated high school	5.01 (9.06)	<.001	1.01 (1.01 - 1.01)
Attended college or technical school	5.01 (8.84)	<.001	1.03 (1.03 - 1.03)
Graduated from college or technical	3.59 (7.15)	<.001	0.88 (0.88 - 0.88)
Other cancer diagnosis		<.001	
No	4.47 (8.28)	<.001	Ref
Yes	4.09 (8.35)	<.001	1.12 (1.08 - 1.14)
Heart disease		<.001	
No	4.31 (8.11)	<.001	Ref
Yes	5.30 (9.55)	<.001	1.33 (1.30 - 1.37)
Lung disease		<.001	
No	3.87 (7.73)	<.001	Ref
Yes	6.67 (9.95)	<.001	1.50 (1.47 - 1.53)
Kidney disease		<.001	
No	4.36 (8.21)	<.001	Ref

Characteristics	Mental health days		
	Mean (SD)	*P* value	aRR[a] (95% CI)
Yes	5.60 (9.63)	<.001	1.28 (1.23 - 1.33)

[a]aOR: adjusted odds ratio.

[b]Ref: reference.

Significant differences in mental health days were observed by race and ethnicity. Black individuals reported the highest average (5.85 d). This group had significantly increased rates of mental health issues compared to White individuals (aRR 1.07, 95% CI 1.01 - 1.13). In contrast, American Indian or Alaska Native participants (aRR 0.82, 95% CI 0.78 - 0.86), multiracial individuals (aRR 0.93, 95% CI 0.88 - 1.00), and Asian respondents (aRR 0.93, 95% CI 0.90 - 0.95) reported fewer mental health days compared to the White reference group.

Women had significantly more poor mental health days (mean 5.18, SD 8.75) compared to men (mean 3.65, SD 7.72). After adjustment, women had substantially higher rates of mental health distress (aRR 1.36, 95% CI 1.34 - 1.39). Respondents aged 65 years and older reported fewer mental health days than those in lower age groups (aRR 0.40, 95% CI 0.40 - 0.41).

BMI was strongly associated with mental health outcomes. Underweight individuals experienced the highest number of poor mental health days (mean 6.40, SD 9.85) and served as the reference group. Compared to them, respondents of normal weight (aRR 0.76, 95% CI 0.71 - 0.82), overweight individuals (aRR 0.71, 95% CI 0.67 - 0.76), and those with obesity (aRR 0.83, 95% CI 0.78 - 0.89) all had significantly lower rates of poor mental health days.

Individuals who did not graduate high school reported the highest average number of poor mental health days (6.13 d), while college graduates reported the fewest number (3.60 d). After adjustment, graduating from college or technical school was associated with significantly fewer mental health days (aRR 0.88, 95% CI 0.88 - 0.88) compared to individuals with less education.

Several comorbid health conditions were also associated with increased mental distress. Individuals with another cancer diagnosis had more poor mental health days (mean 5.01, SD 7.56) and higher adjusted rates compared to those without other cancers (aRR 1.12, 95% CI 1.08 - 1.14). Lung disease was associated with the strongest increase in mental health burden (mean 6.77, SD 7.81; aRR 1.50, 95% CI 1.47 - 1.53). Respondents with kidney disease (aRR 1.28, 95% CI 1.23 - 1.33) and heart disease (aRR 1.33, 95% CI 1.30 - 1.37) also reported significantly higher adjusted rates of poor mental health days compared to their respective reference groups.

Discussion

Principal Findings

In this nationally representative sample, study findings reveal a subtle relationship between nonmelanoma skin cancer and mental health: while individuals with a history of nonmelanoma skin cancer were slightly less likely to report a formal diagnosis of depression in unadjusted comparisons, nonmelanoma skin cancer was not significantly associated with depression after adjusting for demographics, other cancers, and chronic diseases. However, individuals with nonmelanoma skin cancer reported a higher number of poor mental health days before adjustment but slightly fewer poor mental health days after adjustment. These findings suggest that the differences in mental health burden are largely explained by sociodemographic and comorbid factors instead of the nonmelanoma skin cancer itself.

Prior research has suggested that the association between nonmelanoma skin cancer and mental health may operate in both biological and psychological directions. Chronic psychological stress has been shown to alter neuroendocrine-immune pathways, increasing inflammatory activity, impairing wound repair, and weakening immune surveillance, which may elevate susceptibility to certain nonmelanoma skin cancers [6]. However, a nonmelanoma skin cancer diagnosis may contribute to psychological distress through concerns about recurrence, uncertainty during long-term surveillance, scarring, and changes in visible appearance. These have all been documented as drivers of anxiety and depressive symptoms in melanoma and nonmelanoma patient populations [12,13].

A cancer diagnosis itself is often associated with increased stress. Prior research has shown that uncertainty about outcomes and concerns about physical appearance can elevate psychological stress, particularly in patients with visible scars [5,11]. Although stress was not directly measured in this study, the higher number of poor mental health days reported by individuals with nonmelanoma skin cancer may reflect this psychological impact. These findings support the notion that cancer-related stress can appear in daily tasks, even when it does not meet clinical criteria for depression [2,5].

Interestingly, in adjusted models, individuals with a history of nonmelanoma skin cancer reported fewer poor mental health days compared with those without nonmelanoma skin cancer, while no association was observed with depression. Several potential mechanisms may help explain this counterintuitive pattern. Nonmelanoma skin cancer is typically detected early, treated effectively, and associated with excellent long-term outcomes, which may mitigate sustained psychological distress. Successful removal of visible lesions can also create a sense of resolution or restored control, potentially improving daily emotional well-being. In addition, patients with nonmelanoma skin cancer may often engage in regular dermatologic care, providing frequent health care touchpoints that may reduce uncertainty, reinforce preventive health behaviors, and reflect a population with generally higher health literacy or

wellness-oriented behaviors, factors that are linked to more favorable mental health profiles.

The sociodemographic differences observed in this study are consistent with broader public health literature, showing that mental health outcomes are shaped by structural, cultural, and economic factors. Higher rates of poor mental health days among women and younger adults may reflect increased stress, body image concerns, or work-related pressures. Racial variation may be influenced by differences in health care access. Educational and income-related disparities may also reflect gaps in early detection resources. These findings underscore the importance of tailoring mental health support within dermatologic and oncologic care to the needs of various groups rather than applying a uniform approach.

The nature of being diagnosed with nonmelanoma skin cancer itself may contribute significantly to this distress. Patients often experience fear of imperfections due to visible scarring from surgery, concerns about cancer recurrence, or anxiety over potential mortality, especially with melanoma [5,11]. The continuation of dermatological watch and uncertainty with treatments can further elevate emotional strain for individuals. This specifically takes place when the cancer affects visible areas, such as the face or neck [2]. These stressors may not meet the clinical definition of depression but can still influence day-to-day mental well-being [5].

These results align with previous studies that highlight psychological distress among patients with nonmelanoma skin cancer. However, some research has found higher rates of depression, suggesting variability based on sample demographics or methods of measurement [5,11]. This study adds to the conversation by emphasizing subjective mental distress, which may not always manifest as a clinical diagnosis, while also showing that much of the observed association may be explained by comorbid illness and sociodemographic factors.

We also observed key sociodemographic differences. Women, younger adults, individuals with higher BMI, and those with lower levels of education reported a higher number of poor mental health days and higher levels of depression. These outcomes are consistent with a large amount of public health literature and suggest that mental health improvements should be tailored to the vulnerabilities of different subgroups [3,10].

Following these results, a consistent routine of mental health screenings for those diagnosed with nonmelanoma skin cancer is recommended to help relieve mental distress. This may include screening tools such as the Patient Health Questionnaire-9 during dermatology or oncology visits. This incorporates automatic referral pathways to licensed mental health providers with outstanding scores. Integrated care models may also involve co-located behavioral health specialists (eg, psychologists, social workers, or psychiatric nurse practitioners) within dermatology or oncology clinics. Incorporating this may help address psychological needs associated with the diagnosis and its follow-up care. Moreover, support groups, cognitive behavioral therapy, or survivorship counseling should be offered as part of a thorough treatment plan, helping patients manage stressors, such as body image changes, fear, and long-term mental challenges [1,2].

This study has several limitations. As the BRFSS dataset is cross-sectional, the direction of the relationship between nonmelanoma skin cancer and mental health outcomes cannot be established. It is not possible to determine whether poor mental health causes the development of nonmelanoma skin cancer or arises because of diagnosis, treatment, and other factors of nonmelanoma skin cancer. Poor mental health days rely on self-report and capture broad, nonspecific distress, which may not align with clinical diagnoses. Reverse causality is possible if individuals with mental health issues are more likely to seek evaluation for skin changes, leading to higher rates of nonmelanoma skin cancer detection. Additionally, several confounding variables, such as family history of cancer, medication use, and factors such as sun exposure or smoking, were not used in the dataset and may partially explain the observed associations. Although this analysis adjusted for several major chronic illnesses (other cancers, lung disease, heart disease, and kidney disease), many clinically important conditions remain unmeasured. For instance, a participant may have both nonmelanoma skin cancer and a more psychologically burdensome condition, such as lung cancer or severe cardiac disease, which could influence their mental health outcomes. The inability to differentiate whether mental health symptoms stem from nonmelanoma skin cancer itself or from co-occurring illnesses limits the precision of our findings. Additionally, our analyses do not capture illness perceptions, cosmetic concerns, or treatment experiences that may influence psychological outcomes. Future work using datasets with richer clinical detail or linked cancer registry data may help more accurately isolate the independent effect of skin cancer on mental health. These findings should be interpreted as a correlation, and future research is needed to clarify the direction of this relationship. Finally, the BRFSS survey may not capture more nuanced mental health challenges such as anxiety or posttraumatic stress disorder, limiting the depth of insight into the psychological experiences of patients with nonmelanoma skin cancer [5,9]. All variables were self-reported, which may introduce misclassification of both exposures and outcomes.

It is also crucial to recognize that depression is frequently underdiagnosed in community populations, particularly among older adults, men, and individuals with limited access to health care. The BRFSS depression variable relies on self-reported clinical diagnosis, which does not capture unreported cases. More sensitive mental health assessments, such as the Patient Health Questionnaire-9 or validated cancer-specific screening tools, may better capture psychological distress in future studies.

Conclusions

This study highlights a major association between mental health challenges, particularly

depression and poor mental health days, and the presence of nonmelanoma skin cancer among US adults using nationally representative data from the 2023 BRFSS [9]. Adults with a history of skin cancer reported higher unadjusted levels of day-to-day mental distress than those without skin cancer, but analyses adjusted for covariates showed no significant association with depression and a slight decrease in poor mental health days. Moreover, sociodemographic factors play a

substantial role in shaping mental health, with certain groups showing greater vulnerability [3,10].

These results emphasize the importance of integrated care models that address both physical and mental health outcomes in patients with nonmelanoma skin cancer [1,2]. Public health initiatives should prioritize mental health screening and support within dermatologic and oncologic care, especially for disproportionately affected populations. The favorable mental health profile observed among individuals with nonmelanoma skin cancer may also highlight opportunities to leverage routine dermatologic care as a platform for promoting mental well-being and early identification of psychosocial needs. Future research should investigate longitudinal patterns, causal mechanisms, and the effectiveness of mental health interventions in improving quality of life and potentially clinical outcomes among patients with nonmelanoma skin cancer, and whether resilience, health care engagement, or other unmeasured attributes mediate these associations, and whether similar patterns emerge across diverse populations and cancer types [5,11].

Ultimately, recognizing and addressing the mental health burden associated with nonmelanoma skin cancer can lead to more holistic, equitable, and patient-centered care strategies.

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Data Availability

The datasets generated or analyzed during this study are available in the Behavioral Risk Factor Surveillance System repository [8].

Conflicts of Interest

None declared.

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Abbreviations

aOR: adjusted odds ratio
aRR: adjusted rate ratio
BRFSS: Behavioral Risk Factor Surveillance System

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Remote Monitoring of Cryosurgery Response Using a Smartphone App: Prospective Study

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Abstract

Background: Cryosurgery is an effective treatment for benign lesions, although current unstandardized approaches may result in inadequate responses and unwanted adverse reactions. Monitoring treatment characteristics, lesion responses, and patient-reported outcomes using patient-derived mobile imaging may facilitate longitudinal treatment assessment.

Objective: This study aimed to determine the reliability of metrics for assessing the response to cryosurgery in patients with actinic and seborrheic keratoses using remote photographic monitoring.

Methods: Patients who were recommended cryosurgery by their physician for treating seborrheic and/or actinic keratoses (22 patients with 31 lesions) were enrolled. After treatment, participants took “overview” and “close up” photos of their lesion(s) and rated appearance, pain, and degree bothered on a custom smartphone app at eight posttreatment time points (days 0, 3, 7, 10, 14, 30, 60, and 90). After study completion, independent raters scored the images for local skin response (eg, erythema, scaling, crust, swelling, vesiculation, and erosion), cosmetic outcome (eg, hyperpigmentation, hypopigmentation, scarring, and atrophy), and lesion resolution.

Results: The local skin response peaked 3 days after cryosurgery, with 26% (7/27) of patients reporting pain. There was substantial agreement between raters for lesion resolution (κ=0.71, 95% CI 0.62 - 0.79), erythema (κ=0.66, 95% CI 0.57-0.74), and the local skin response index (κ=0.69, 95% CI 0.61-0.77) as measured using the quadratic-weighted Cohen κ. Overall, 77% (151/195) of submitted photos were good quality, and most image-derived metrics showed higher agreement in good-quality photos (8/14, 57% metrics had moderate-substantial κ) compared to poor-quality photos (4/14, 29% metrics had moderate-substantial κ). The peak local skin response had a moderate positive association with the lesion response at 90 days (Spearman ρ=0.556, *P*=.01).

Conclusions: This study demonstrates the utility of patient self-imaging for longitudinal assessment of the response to cryosurgery.

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KEYWORDS

cryosurgery; cryotherapy; keratoses; tele-dermatology; remote monitoring; local skin response; lesions; patient care; mobile imaging; erythema; skin response

Introduction

Nonsurgical therapies remain the mainstay for many symptomatic benign or precancerous lesions, including actinic or seborrheic keratoses. Cryosurgery is an effective treatment for isolated keratoses and remains the most commonly used destructive modality [1]. However, current unstandardized approaches to freezing techniques may result in inadequate responses and unwanted adverse reactions [2-4]. This highlights the need for more systematic approaches that can optimize treatment outcomes while incorporating patient preferences.

Store-and-forward mobile apps are increasingly used for therapeutic evaluation and research photo-documentation in dermatology [5-7]. This technology offers benefits by reducing geographical limitations and time constraints that make longitudinal research difficult. Beyond facilitating remote lesion monitoring, they can be utilized to document cutaneous events in response to therapeutics while decreasing barriers to follow-up. Our study aimed to evaluate the agreement of image-derived grading of lesion responses and to investigate their correlation with patient-reported adverse reactions in those with actinic and seborrheic keratoses treated with cryosurgery utilizing patient-submitted images.

Methods

Study Design

This was a prospective, single-center, observational study undertaken at the Memorial Sloan Kettering dermatology clinic in New York City from October 2021 to June 2023. Patients were included if they were at least 18 years of age with at least one seborrheic or actinic keratosis undergoing destructive treatment and who could either take a photo of their lesion themselves or have a partner do so. Exclusion criteria included not having access to an iPhone or the inability of the patient or their partner to photograph the lesion. Prior to the study, patient eligibility was assessed.

Ethical Considerations

This study was reviewed and approved by the Memorial Sloan Kettering Cancer Center's Institutional Review Board (Protocol #21‐019). All participants provided written informed consent for participation and publication of their case details, and the research was conducted in accordance with principles embodied in the Declaration of Helsinki and in accordance with local requirements. Analytic data and images submitted via the mobile app were linked to deidentified study identifiers only. Participants received no financial compensation for participation in the study.

Data Collection

Patients were trained to use a smartphone-based self-imaging app (Canfield Capture Mobile App; Canfield Scientific, Inc). Before cryosurgery, participants took baseline overview and close-up photographs of up to three lesions in clinic using the app. After receiving provider-administered cryosurgery using variable techniques, patients were asked to remotely continue photographing lesions and complete a symptom questionnaire (rating pain, degree bothered, and cosmesis) at eight posttreatment time points (days 0, 3, 7, 10, 14, 30, 60, and 90) using the app. A standardized imaging protocol emphasizing consistent lighting, positioning, and focus was suggested. Full instructions, photo quality checklists, and questionnaire items given to the patients are available in Multimedia Appendix 1.

Independently Rated Measurements

Paired pre- and posttreatment images were independently reviewed by two board-certified dermatologists using a structured scoring rubric. Reviewers assessed lesion resolution, local skin response (LSR; including erythema, crusting, swelling, vesiculation/pustulation, erosion/ulceration, and flaking/scaling), and photo quality (good vs poor) across the eight time points. Each image pair was assigned both individual scores (0-4) and a composite LSR index (range 0-24). The lesion response was classified as a binary outcome (complete vs incomplete) and using a four-point scale, which were both used to score the response. Ratings were completed using a standardized interface with anonymized, time-randomized images to reduce bias. The full scoring criteria, interface set up, and workflow can be found in Multimedia Appendix 2.

Statistical Analysis

The primary objective was to assess whether lesion resolution can be reliably evaluated through patient-captured photographs. The quadratic-weighted Cohen κ was used to measure the interrater agreement of lesion resolution (incomplete vs complete), as well as other visually determined posttreatment cutaneous gradings across all time points. The Spearman rank correlation was used to evaluate the relationships between the physician-rated skin responses and the patient-reported adverse reactions. A principal component analysis was conducted to capture significant variance and patterns in the data collected for peak response values and lesion outcomes at day 90. All statistical analysis was performed with R software (version 4.3.1; R Foundation for Statistical Computing) using the following packages: *dplyr*, *tidyverse*, *psych*, *ggplot2*, *stats*, and *table1*.

Results

Study Population

A summary of patient characteristics can be found in Table 1. We enrolled 22 patients with 31 total lesions (18 seborrheic keratoses and 13 actinic keratoses). Patients had Fitzpatrick skin types II-IV. The cryosurgery apertures used included A, B, C, 20 gauge, 22 gauge, and angiocath. Lesions were treated with liquid nitrogen using a mean distance of 1.63 (range 1.00-3.00) cm, 1 or 2 cycles, with an average spray time of 9.84 (SD 5.46) seconds. At 90 days, the participation rate was 68% (21/31 lesions).

Table . Demographic characteristics.

	Seborrheic keratosis (n=18), n (%)	Actinic keratosis (n=13), n (%)	Overall (N=31), n (%)
Age range (years)			
50 - 64	5 (27.8)	3 (23.1)	8 (25.8)
65 - 79	13 (72.2)	8 (61.5)	21 (67.7)
≥80	0 (0)	2 (15.4)	2 (6.5)
Skin type			
II	12 (66.7)	12 (92.3)	24 (77.4)
III	5 (27.8)	1 (7.7)	6 (19.4)
IV	1 (5.6)	0 (0)	1 (3.2)
Site			
Head/neck	8 (44.4)	4 (30.8)	12 (38.7)
Anterior torso	1 (5.6)	1 (7.7)	2 (6.5)
Posterior torso	2 (11.1)	0 (0)	2 (6.5)
Lateral torso	4 (22.2)	0 (0)	4 (12.9)
Upper extremity	0 (0)	5 (38.5)	5 (16.1)
Lower extremity	3 (16.7)	3 (23.1)	6 (19.4)
Lesions available for analysis[a]			
Day 0	16 (88.9)	12 (92.3)	28 (90.3)
Day 3	17 (94.4)	10 (76.9)	27 (87.1)
Day 7	17 (94.4)	9 (69.2)	26 (83.9)
Day 10	17 (94.4)	10 (76.9)	27 (87.1)
Day 14	16 (88.9)	8 (61.5)	24 (77.4)
Day 30	16 (88.9)	8 (61.5)	24 (77.4)
Day 60	17 (94.4)	5 (38.5)	22 (71.0)
Day 90	15 (83.3)	6 (46.2)	21 (67.7)

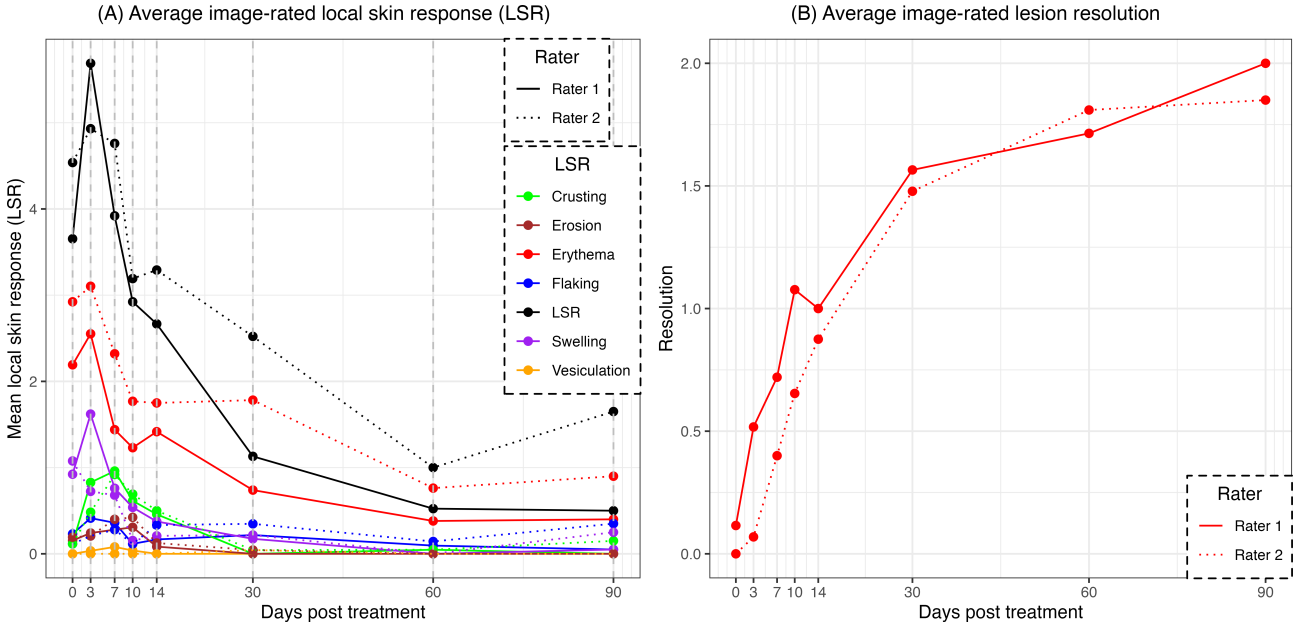
[a]Completion rate defined as the proportion of treated lesions with evaluable image submissions available at each posttreatment time point, relative to the total number of treated lesions at baseline.

Cryosurgery Efficacy and Tolerability

The frequency of image-rated metrics across all time points is listed in Multimedia Appendix 3. Erythema, flaking, scaling, crusting, and swelling were observed in >50% of lesions, with erythema (27/29, 93%) and swelling (24/29, 83%) being the most commonly observed effects. Vesiculation, atrophy, and scarring were observed in ≤10% of lesion responses. Figure 1A shows the time course of the mean LSR for rater 1 and rater 2. The LSR peaked at day 3, with erythema having the highest mean (mean 2.58, SD 1.3 for rater 1, and mean 3.10, SD 1.5 for rater 2) and vesiculation having the lowest mean (mean 0.04, SD 0.2 for rater 1, and mean 0.00, SD 0.0 for rater 2). Figure 1B shows the average lesion response over time. At 90 days, 32% (6/19) of the lesions were considered resolved by both raters and 58% (11/19) of the lesions were considered resolved by at least one rater.

Multimedia Appendix 4 shows the patient-rated adverse reactions over time. At 3 days, 26% (7/27) of the patients reported pain, 19% (5/27) reported being bothered by adverse reactions, and 37% (10/27) reported cosmetic outcomes as “poor” or “fair.” At 90 days, 71% (15/21) of the patients reported no pain, 76% (16/21) reported very good or excellent cosmetic outcomes, and 100% (21/21) reported they were not bothered by adverse reactions.

Figure 1. Average image-rated local skin response (LSR) following cryosurgery treatment. (A) The mean image-rated LSR for rater 1 and rater 2 following cryosurgery. The individual LSR metrics were rated on a scale of 0 (none or at baseline) to 4. The LSR is a composite of the scores for crusting, erosion, erythema, scaling or flaking, swelling, and vesiculation (0 - 24). The LSR was the highest between days 0 and 7 after treatment, peaking on day 3, and largely resolved by day 60. Erythema presented as the predominant symptom, while vesiculation was the least common. (B) The mean image-rated lesion response for rater 1 and rater 2 following cryosurgery. The lesions were rated from 0 (no change) to 3 (complete resolution). At 90 days, 58% (11/19) of the lesions were considered resolved by at least one rater.



Reliability of Image-Rated Metrics

Table 2 shows the interrater agreement for image-derived metrics of the cryosurgery response. Overall, there was substantial agreement for lesion resolution using a four-point scale (κ=0.71), composite LSR (κ=0.69), and erythema (κ=0.66). Vesiculation, hyperpigmentation, hypopigmentation, and atrophy had negligible agreement.

Table 3 shows the interrater agreement by photo quality. Good-quality photos (n=151) consisted of photo sets where the quality was graded as "good" by both raters. Poor-quality photos (n=44) consisted of sets where at least one person graded the quality as "poor." Lesion resolution (scored as completed or incomplete) was more reliable for good-quality photos compared to poor-quality photos (κ=0.64 vs κ=0.14). Although several image-rated response metrics had higher agreement in good-quality photos (including the LSR index, erythema, erosion, scaling, and swelling), crusting, flaking, and hyperpigmentation had similar or slightly higher agreement in poor-quality photos.

Table . Interrater agreement for image-derived metrics of cryosurgery response (n=195).

Image derived metric	κ value[a]	95% CI
Four point scale		
Lesion resolution[b]	0.71	0.62 to 0.79
Complete versus incomplete		
Lesion Resolution	0.56	0.41 to 0.72
Local skin response metrics		
Erythema	0.66	0.57 to 0.74
Crusting	0.52	0.35 to 0.69
Local skin response composite	0.69	0.61 to 0.77
Erosion	0.47	0.20 to 0.73
Scaling	0.42	0.19 to 0.65
Swelling	0.40	0.23 to 0.58
Flaking	0.24	−0.006 to 0.48
Vesiculation	−0.006	−0.016 to 0.0042
Hyperpigmentation	−0.024	−0.043 to −0.0055
Hypopigmentation	−0.0074	−0.021 to 0.0062
Atrophy	−0.0059	−0.016 to 0.0042
Scarring	N/A[c]	N/A

[a]Interpretation of κ values: 0-0.20 (slight), 0.21-0.40 (fair), 0.41-0.60 (moderate), 0.61-0.80 (substantial), and 0.81-1.00 (almost perfect).

[b]Lesion resolution was graded at four levels (incomplete, <50%, >50%, and complete) and as a binary outcome (complete resolution vs incomplete resolution).

[c]N/A: not applicable.

Table . Interrater agreement for image-derived metrics of cryosurgery response by quality (n=195).

Image derived metric	Good-quality image (n=151)		Poor-quality image (n=44)	
	κ value[a]	95% CI	κ value	95% CI
Four point scale				
Lesion resolution[b]	0.75	0.66 to 0.84	0.50	0.278 to 0.73
Complete versus incomplete				
Lesion resolution	0.64	0.48 to 0.80	0.14	−0.23 to 0.52
Local skin response metrics				
Erythema	0.68	0.59 to 0.77	0.51	0.265 to 0.75
Crusting	0.50	0.30 to 0.70	0.60	0.29 to 0.91
Local skin response composite	0.70	0.62 to 0.79	0.62	0.402 to 0.85
Erosion	0.54	0.29 to 0.79	−0.019	−0.048 to 0.0155
Scaling	0.47	0.20 to 0.73	0.23	−0.11 to 0.57
Flaking	0.22	−0.039 to 0.48	0.31	−0.16 to 0.77
Swelling	0.42	0.211 to 0.62	0.36	0.029 to 0.68
Vesiculation	−0.0076	−0.021 to 0.0055	N/A[c]	N/A
Hyperpigmentation	−0.024	−0.047 to −0.0008	−0.031	−0.066 to 0.0040
Hypopigmentation	−0.0089	−0.025 to 0.0071	N/A	N/A
Scarring	N/A	N/A	N/A	N/A
Atrophy	−0.0067	−0.018 to 0.0045	N/A	N/A

[a]Interpretation of κ values: 0-0.20 (slight), 0.21-0.40 (fair), 0.41-0.60 (moderate), 0.61-0.80 (substantial), and 0.81-1.00 (almost perfect).

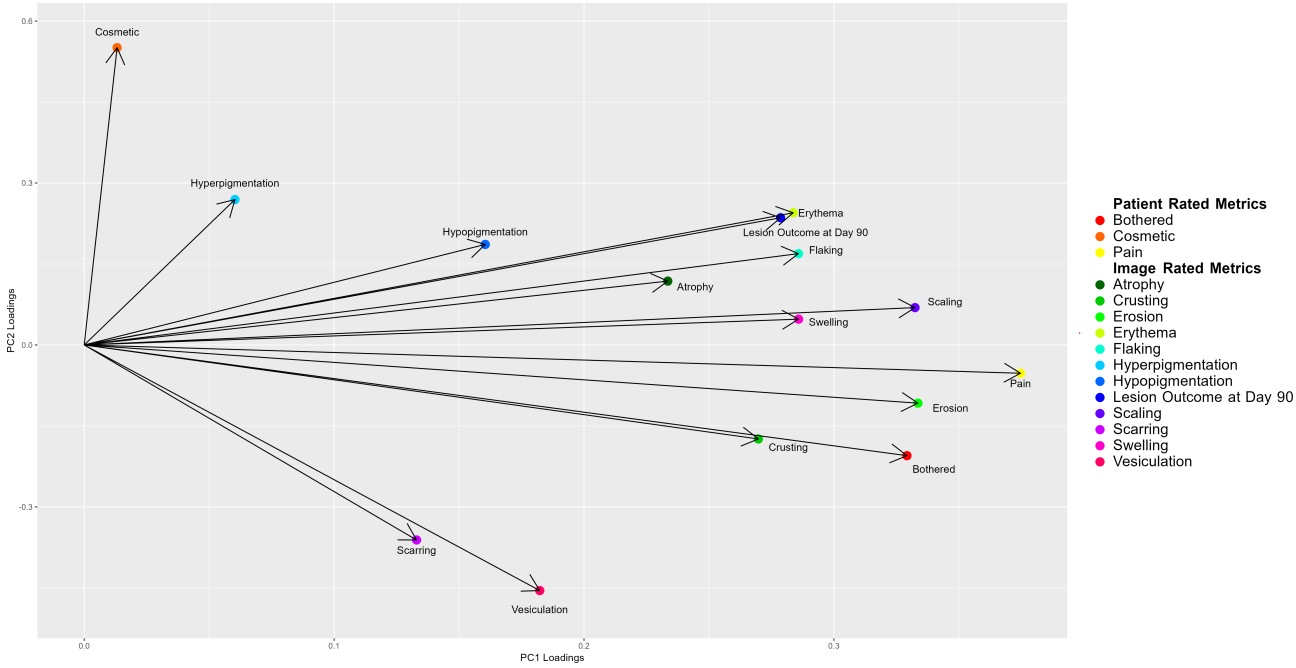
[b]Lesion resolution was graded at four levels (incomplete, <50%, >50%, and complete) and as a binary outcome (complete resolution vs incomplete resolution).

[c]N/A: not applicable.

Predictors of Lesion Response and Patient-Rated Side Effects

Peak responses for image-rated metrics were determined by averaging the highest grades assigned by rater 1 and rater 2 across all time points. Peak values for patient-rated adverse reactions were determined by identifying the maximum scores reported for cosmetic impact, level of bother, and pain across all time points. The peak LSR score had a moderate positive association with the lesion response at 90 days (Spearman ρ=0.556, *P*=.01), a moderate positive association with maximum pain (Spearman ρ=0.643, *P*<.001), and a moderate positive association with the maximum rated degree bothered (Spearman ρ=0.545, *P*=.002), all suggesting that lesions with a higher visually assessed LSR score are more likely to be painful, bothersome, and appear resolved long term. The cosmetic outcome at 90 days was also moderately associated with lesion outcome at 90 days (Spearman ρ=0.591, *P*=.008). Figure 2 shows principal component analysis of peak image-based metrics, peak patient-rated adverse reactions, and lesion resolution at day 90. A biplot of principal component 1 and principal component 2 loadings shows that the lesion outcome at day 90 is most closely clustered with peak erythema, suggesting that changes associated with increased local redness may be the most important factor for long-term lesion resolution. Pain is closely clustered with erosion, and being bothered is closely clustered with crusting.

Figure 2. Biplot of principal component analysis loadings for peak image-rated outcomes and patient-reported adverse reactions. This biplot showcases the first two principal components for principal component analysis performed on the peak local skin response values and patient-reported outcomes with the 90-day lesion resolution (26 lesions). The vector direction indicates the pattern of variance, and the length denotes the strength of contribution to the principal component. The variable "Erythema" is closely clustered with the "Lesion Outcome at Day 90," indicating its potential as a predictor of long-term resolution. Additionally, "Pain" is closely clustered with "Erosion," and "Bothered" is closely clustered with "Crusting," reflecting a shared variance among these adverse reactions. PC: principal component.



Discussion

Principal Findings and Comparison With Prior Work

The findings of this study support the feasibility of using store-and-forward photos for remotely documenting lesion response to destructive therapy. In summary, we found that the image-derived response of keratoses to cryosurgery can be reliably labeled using photos submitted by patients, and that the LSR metrics correlate with patient-reported outcomes like pain and long-term lesion resolution. Several parameters, such as lesion response, the LSR index, and erythema, showed substantial agreement between raters. However, the agreement was minimal for vesiculation, hyperpigmentation, and hypopigmentation, although these were rare events and may have been underpowered to detect any significant agreement. When comparing the agreement of image-derived metrics by photo quality, a higher concordance was noted for lesion resolution and several other response indicators for high-quality photos. However, several response metrics did not vary by photo quality. This suggests that even with a standardized grading system, both rater judgment and photo quality may influence grading of lesion response.

Of the submitted images, 77% (151/195) were deemed adequate for assessment. This surpasses a recent study where 55.1% (1985/3600) of patients submitted photos of various rashes or lesions that were of sufficient quality for medical decision-making [8]. The design of the mobile app, which provided access to baseline images and quality reminders, along with explicit instructions, likely contributed to image quality. We previously reported on the usability of the app in the first 8 patients, who reported ease of use with a mean score of 4.4 out of 5 [9].

Cryosurgery treatment is unstandardized, and our results showed a wide range of apertures, spray times, spray distances, and cycles. This may lead to inadequate treatment for patients and/or bothersome adverse reactions. In our study, 58% of lesions were considered resolved by at least one rater, slightly below the reported rates of 63% to 88% [10-15]. Still, cryosurgery was well tolerated at day 90, although it is worth noting that a subset of patients still reported long-term pain. Reported tolerability of cryosurgery varies widely, with a recent meta-analysis documenting pain or burning in 7% to 22% of cases, crusting in 6%, and discoloration or scarring in 33% [10-16]. This shows there still may be a subset of patients who experience long-term sequelae and highlights the need for personalized treatment approaches to minimize adverse effects, although this study is not powered to evaluate those specifics.

The lesion outcome at 90 days was moderately associated with the peak LSR, highlighting that more robust inflammation may lead to greater long-term resolution. As the LSR appeared to peak between day 3 and day 7, early virtual follow-up may offer insights into the probability of long-term resolution. Still, principal component analysis suggests that lesion resolution may not be closely associated with peak patient-reported outcomes of pain, cosmesis, and degree bothered, highlighting the utility of image-based approaches to evaluate treatment efficacy. Future studies may aim to utilize machine learning approaches that combine reliable image-based metrics with patient-reported outcomes to predict treatment success [17].

Limitations

The study faced limitations; most notably, there was a lack of diversity of skin type, which is important to study because both imaging and response to destructive therapy can vary based on skin type or tone. Future studies should aim to recruit patients that reflect the general population and include destructive therapies often used for patients of darker skin tones (eg, electrodessication). This study is also limited by its small sample size and the lack of in-person assessments. Specifically, a diagnosis of keratosis often relies on tactile cues that were not conducted during follow-up. Additionally, visual assessment of lesion resolution was sometimes difficult to distinguish from persistent posttreatment cosmetic adverse reactions (eg, erythema, crusting, and pigment alterations), which could have affected the grading of both lesion resolution and/or LSR. Lastly, the generalizability of the study is limited by the small number of raters and the single-center setting.

Conclusions

Our research demonstrates that certain image-derived skin response metrics can be reliably labeled from patient-submitted photos and are associated with both lesion responses and some patient-reported outcomes. These findings emphasize the potential of teledermatology for assessing the response to destructive therapies and highlight the limitations of visual grading of the LSR from non-standardized photos. These findings pave the way for future studies aimed at integrating image-based and patient-rated metrics for outcome assessment.

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Data Availability

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

Authors' Contributions

Conceptualization: VW, EAC, TS, MDS, LG, MCG, NRK, VR, ACH
Data curation: VW, EAC, TS, MDS, LG
Methodology: VW, EAC, TS, MDS, LG, MCG, NRK, VR, ACH
Supervision: VR, ACH
Writing – original draft: VW

Conflicts of Interest

VW, TS, EAC, MCG, LG, MDS, and NRK have no disclosures to report. VR is an expert advisor for Inhabit Brands and Atria Institute and receives research funding from Lutris Pharma, Kaggle, and the AWS Open Data Program. ACH is a medical consultant for Canfield Scientific Inc. and Scibase and has an equity stake in SpotDoc.

Multimedia Appendix 1
Patient self-imaging protocol and survey instrument.
[DOCX File, 171 KB - derma_v9i1e63467_app1.docx]

Multimedia Appendix 2
Image-based rater grading instructions and interface.
[DOCX File, 1125 KB - derma_v9i1e63467_app2.docx]

Multimedia Appendix 3
Frequency of image-derived metrics by rater agreement.
[DOCX File, 19 KB - derma_v9i1e63467_app3.docx]

Multimedia Appendix 4
Patient-rated side effects over time.
[DOCX File, 120 KB - derma_v9i1e63467_app4.docx]

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Abbreviations

LSR: local skin response

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Patient Satisfaction, Side Effects, and Other Reactions Reported by Adult Men Prescribed Compounded Topical Finasteride via a National Telehealth Platform: Retrospective Analysis of Real-World Data

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Abstract

Background: Topical minoxidil and oral finasteride are approved by the US Food and Drug Administration (FDA) for the treatment of male androgenetic alopecia (AGA). However, concerns about adverse events related to the use of oral finasteride have led to some apprehension about the treatment. Topical finasteride, though not FDA-approved, has demonstrated efficacy and safety in a limited number of clinical trials and may be a promising alternative, such that compounding pharmacies and telehealth companies in the United States now offer access to topical finasteride for patients with AGA.

Objective: This real-world, retrospective study is, to our knowledge, the largest study to date aimed to evaluate patient satisfaction and tolerability associated with the novel combinations of topical finasteride and topical minoxidil for the treatment of male AGA.

Methods: We conducted a retrospective analysis of patient data collected during routine clinical follow-up via Hims & Hers, a direct-to-consumer health and wellness platform, between April 1, 2021 and April 30, 2025 to assess the frequency of side effects and other possible medication reactions associated with the use of compounded topical finasteride and minoxidil. Data were gathered from two sources: (1) a follow-up check-in sent to patients approximately 130 days following the initiation of treatment; (2) unprompted communications sent via in-app or web-based messaging from patients to their care team. Data about patient satisfaction with treatment, the frequency of any side effect, frequency of specific side effects, need for a higher level of care, and treatment discontinuation due to a side effect were extracted from the data sources.

Results: A total of 638,629 male patients with AGA received a prescription for a compounded topical finasteride and minoxidil product between April 1, 2021 and April 30, 2025. Of 151,352 (23.7%) patients who completed a follow-up check-in, 121,615 (80.4%) reported being satisfied with treatment and 4034 (2.7%) reported experiencing a side effect. Of all the 638,629 patients, 230 (0.04%) sent their care team a message (outside of check-ins) indicating a side effect or other possible medication reactions. No patient reported seeking a higher level of care or discontinued treatment due to such an occurrence.

Conclusions: Patients prescribed novel formulations of compounded topical finasteride and minoxidil for the treatment of AGA via a national telehealth platform reported satisfaction with the treatment and tolerated it well. The limitations of the study include the use of retrospective data and the lack of a control group, both of which preclude causal inference. Future research should include randomized controlled trials to assess the efficacy, safety, and tolerability of topical finasteride.

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KEYWORDS

androgenetic alopecia; topical finasteride; topical minoxidil; patient satisfaction; side effects; telehealth

Introduction

Androgenetic alopecia (AGA), commonly referred to as "male pattern baldness," is the most common form of hair loss in men. It affects approximately 50% of men worldwide [1] and an estimated 50 million in the United States alone [2]. Although AGA is considered a physically benign medical condition, it is associated with notable psychological consequences including

low self-esteem, body dissatisfaction, social anxiety, and reduced quality of life [3].

Topical minoxidil and oral finasteride are two treatments currently approved by the US Food and Drug Administration (FDA) for the treatment of AGA. Topical minoxidil is available in both 2% and 5% formulations; the 5% formulation has been shown to be significantly superior in increasing hair regrowth, with an earlier response to treatment and good tolerance [4]. Oral finasteride has been shown, in clinical trials, to be well tolerated and effective in stabilizing hair loss and promoting hair growth [5]; however, reports of certain treatment-related adverse events such as sexual side effects and depression have led to some apprehension about the treatment, which may be negatively affecting the number of individuals who could benefit from it [6]. Notably, recent studies have questioned the purported causal relationship between oral finasteride and psychiatric symptoms [7,8].

Topical finasteride may be a promising alternative to oral finasteride. Though limited in number, studies that have examined the use of topical finasteride in the treatment of AGA have found it to be an effective and safe treatment option [9]. Two randomized controlled trials (RCTs) found topical finasteride to significantly decrease the rate of hair loss and significantly improve hair count compared to the placebo, with no differences in the incidence of adverse events or treatment discontinuation between the two groups [10,11]. Plasma concentrations of finasteride were 100-fold lower with the topical application of 0.25% finasteride spray versus 1 mg oral finasteride [11]. Furthermore, a systematic review of available RCTs, prospective studies, and retrospective medical record reviews found topical finasteride, either alone or in combination with other agents including topical minoxidil, to be non-inferior to oral finasteride and well-tolerated by patients—with the authors calling for larger cohort studies to examine the potential adverse event profile of the drug [9].

Unlike oral finasteride, topical finasteride is not currently FDA-approved for the treatment of AGA. It is, however, available as a compounded medication for those who do not want to take an oral medication or might be concerned about the reported side effects associated with oral finasteride. Several compounding pharmacies and telehealth companies in the United States now offer access to topical finasteride for patients with AGA. This real-world retrospective study is, to our knowledge, the largest study to date on patient satisfaction and tolerability associated with novel combinations of topical finasteride and topical minoxidil for the treatment of male AGA. We review anonymized patient data collected during the course of routine clinical care via a direct-to-consumer telemedicine platform to understand the patient-reported satisfaction and frequency of side effects and other possible medication reactions associated with compounded topical finasteride use (compounded topical finasteride is not FDA-approved or evaluated for safety, efficacy, or quality by the FDA).

Methods

Study Overview

Hims & Hers is a direct-to-consumer health and wellness platform that aims to increase access to treatment for adults aged 18 years and older with traditionally stigmatized conditions, including hair loss. Prospective patients seeking hair loss treatment come to the platform and complete a comprehensive clinical intake. Once the intake process is complete, a licensed medical provider thoroughly reviews the information gathered during the intake process, including medical history and treatment preferences, and has the opportunity to follow-up with the patient with any questions or remaining information deemed necessary to provide care. The provider then makes an independent clinical determination as to whether treatment is appropriate, and, if appropriate, shares a diagnosis and treatment plan. All licensed medical providers furnishing care through the platform are employed or contracted by You Health, a professional corporation owned and managed by licensed health care providers, which is the provider network associated with the platform. Patients sign up for a subscription to receive their medication dispensed by a licensed pharmacy at regular intervals. With this subscription, patients have ongoing, unlimited access to their care team via messaging and are sent follow-up check-ins to assess their treatment experience.

As of June 2025, three compounded topical finasteride and minoxidil products were available via the Hims & Hers platform to treat adult men with AGA: a spray consisting of 0.3% topical finasteride and 6% minoxidil, to be sprayed four times on the individual's affected scalp area once per day; a spray consisting of 0.3% topical finasteride, 7% minoxidil, 2.2% ketoconazole, and 0.2% biotin, to be sprayed four times on the individual's affected scalp area once per day; and a serum consisting of 0.3% topical finasteride and 6% minoxidil, 1 mL of which to be massaged into the individual's affected scalp area once per day. All patients prescribed a compounded topical finasteride and minoxidil product were made aware that the product was not FDA-approved and were provided with instructions for use as well as education regarding what to expect with the treatment, common side effects, and other precautions. Patients also had access to educational treatment information via the Hims & Hers app and could contact their care team at any time with questions or concerns. In April 2025, the FDA issued an alert to health care providers, compounders, and consumers regarding potential risks associated with the use of compounded topical finasteride. This information was also shared with patients to ensure transparent communication regarding the products available through the platform.

To assess the frequency of side effects and other possible medication reactions associated with the use of compounded topical finasteride and minoxidil available via the Hims & Hers platform, we conducted a retrospective analysis of patient data collected during the course of routine clinical follow-up via the platform between April 1, 2021 and April 30, 2025. As this was an analysis of data gathered from individuals actively engaged in treatment, there was no control group.

Data Collection

The analysis included two sets of data. The first set of data consisted of responses to a follow-up check-in assessment sent to patients approximately 130 days following treatment initiation. The check-in queried patients about their treatment satisfaction and experience with side effects. To assess treatment satisfaction, patients were asked to indicate "yes" or "no" to the following prompt: "I'm happy with the way my treatment is working." To assess experience with side effects, patients were asked to respond "yes" or "no" to the following question: "Are you bothered by any side effects or other negative reactions from your treatment?" No other questions pertaining to side effects were included in the check-in.

The second set of data consisted of unprompted communications sent via in-app or web-based messaging from patients to their care team. Patients can send these unprompted messages at any time for review by the care team. These communications undergo continuous quality assurance by a clinical quality team that monitors patient messages in real-time for mention of side effects or other possible medication reactions and follows-up as appropriate. Their work includes validating the data to ensure that such events are appropriately recorded—for example, that the side effects and reactions reported are reported by patients in relation to one of the topical finasteride and minoxidil products highlighted in this analysis. Utilizing both sets of data ensured that all occurrences, both solicited and spontaneously reported by patients, were included in the analysis.

Statistical Analysis

Descriptive statistics using Google Colab (Mountain View, CA) were used to quantify the percentage of patients who reported satisfaction with treatment in their follow-up check-in, the percentage of patients who reported having been bothered by side effects or other negative reactions in their follow-up check-in, the percentage of patients who indicated experiencing a side effect or other possible medication reaction in messages to their care team, the percentage of patients who sought a higher level of care due to such a reaction, and the percentage of patients who discontinued treatment due to such a reaction. For results regarding the percentages of patients who reported treatment satisfaction and side effects in their follow-up check-in, the number of patients who completed a check-in is used as the sample size. For results regarding the percentage of patients who reported a side effect to their care team, the total number of patients prescribed a compounded topical finasteride product is used a the sample size. This is due to the fact that all patients had the ability to message their care team; thus, all patients can be included in the denominator.

Ethical Considerations

This study was approved by the WCG Institutional Review Board (Protocol 001, Review 20244102). All study procedures were conducted in accordance with the principles of the Declaration of Helsinki. The study protocol included a Waiver of Informed Consent, as all data analyzed were collected during the course of routine care and de-identified prior to analysis. Patients were not compensated for their participation in this study.

Results

Baseline Demographics

A total of 638,629 male patients with AGA received a prescription for a compounded topical finasteride and minoxidil product between April 1, 2021 and April 30, 2025. A total of 151,352 completed the follow-up check-in querying patients about their treatment satisfaction and experience with side effects.

The mean (SD) age of all patients who received a prescription for a compounded topical finasteride product (n=638,629) was 39.6 (11.9) years, while the mean (SD) age of those who completed the follow-up check-in (n=151,352) was 41.2 (11.8) years.

Treatment Satisfaction and Side Effects as Reported During Follow-Up Check-In

Overall, 121,615 (80.4%, n=151,352, 95% CI [80.2%, 80.6%]) patients who completed the follow-up check-in reported being satisfied with their treatment. A total of 4034 (2.7%, n=151,352, 95% CI [2.6%, 2.8%]) reported experiencing side effects.

Of the 151,352 patients who completed the follow-up check-in, 138,645 had been prescribed the 0.3% topical finasteride and 6% minoxidil spray; 10,774 had been prescribed the 0.3% topical finasteride, 7% minoxidil, 2.2% ketoconazole, and 0.2% biotin spray; and 1933 had been prescribed the 0.3% topical finasteride and 6% minoxidil serum. Table 1 outlines treatment satisfaction and the frequency of side effects reported by patients receiving each treatment.

Table . Treatment satisfaction and frequency of side effects reported by patients during follow-up check-ins.

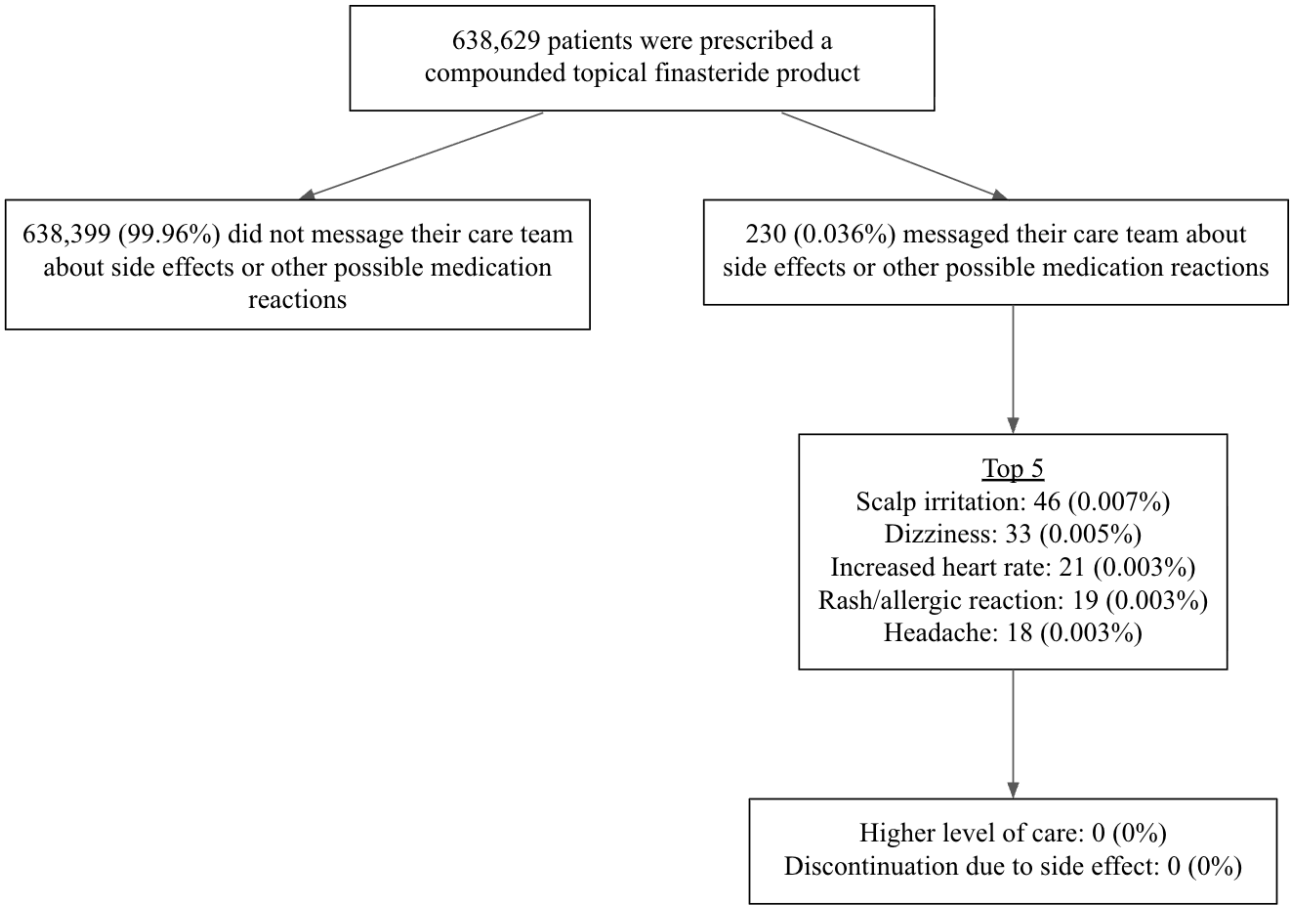
	All topical finasteride treatments (n=151,352)	Topical finasteride (0.3%) and minoxidil (6%) spray (n=138,645)	Topical finasteride (0.3%), minoxidil (7%), ketoconazole (2.2%), and biotin (0.2%) spray (n=10,774)	Topical finasteride (0.3%) and minoxidil (6%) serum (n=1933)
Treatment satisfaction, n (%)	121,615 (80.4)	111,165 (80.2)	8900 (82.6)	1550 (80.2)
Experienced side effects, n (%)	4034 (2.7)	3716 (2.7)	251 (2.3)	67 (3.5)

Side Effects and Other Possible Medication Reactions Reported in Patients' Communications to Their Care Team

Of the 638,629 patients prescribed a compounded topical finasteride and minoxidil product, 230 (0.04%, n=638,629, 95% CI [0.035%, 0.045%]) sent their care team messages concerning side effects or other possible medication reactions. The most commonly reported occurrences were scalp irritation (46/638,629, 0.007%, 95% CI [0.0064%, 0.0076%]), dizziness (33/638,629, 0.005%, 95% CI [0.0045%, 0.0055%]), increased heart rate (21/638,629, 0.003%, 95% CI [0.0026%, 0.0035%]), rash or some allergic reaction (19/638,629, 0.003%, 95% CI [0.0026%, 0.0035%]), and headache (18/638,629, 0.003%, 95% CI [0.0026%, 0.0035%]). Sexual side effects, specifically decreased libido and erectile dysfunction, were reported by 12/638,629 patients (0.002%, 95% CI [0.0017%, 0.0023%]). Depression was reported by 13/638,629 patients (0.002%, 95% CI [0.0017%, 0.0023%]). Anxiety was reported by 10/638,629 patients (0.002%, 95% CI [0.0017%, 0.0023%]). Cognitive concerns were reported by 10/638,629 patients (0.002%, 95% CI [0.0017%, 0.0023%]).

No patients reported seeking a higher level of care (eg, emergency room or urgent care visit) related to a side effect or other possible medication reaction. No patients reported discontinuing treatment due to such an occurrence. During the study period, 1 spouse reported the death of a partner. Upon follow-up, no cause was identified and no causality was established. Figure 1 provides a summary of the side effects and other possible medication reactions reported by patients via messaging.

Figure 1. Schematic of side effects and other possible medication reactions reported by patients in messages to their care team.



Discussion

In this largest study of patient satisfaction and tolerability associated with the use of novel compounded formulations of topical finasteride and minoxidil, we found that 80% of those who completed a follow-up check-in reported satisfaction with treatment and less than 3% reported experiencing side effects. An additional 0.04% of patients sent their care team messages concerning side effects or other medication reactions. The most common reactions appeared to fall into one of two categories: (1) scalp irritation and rash, likely associated with the route of administration; (2) dizziness, increased heart rate, and headache, likely attributable to minoxidil acting as a vasodilator. Of note, sexual side effects, depression, anxiety, and cognitive concerns previously associated with oral finasteride were reported by just 0.002% of patients. There were no reports of "post-finasteride syndrome" [12].

Early clinical trials of 1 mg oral finasteride for the treatment of male AGA found that 3.8% of participants experienced adverse events possibly, probably, or definitely related to treatment, specifically decreased libido, erectile dysfunction, and ejaculation disorder, and 1.4% discontinued treatment due to such adverse events [13]. Trials of 2% topical minoxidil for the treatment of male AGA found that the most common adverse events were minor respiratory events such as colds and

respiratory infections (3.37% of participants), followed by dermatological reactions such as itching (1.94%) [14]. Trials of 5% topical minoxidil for the treatment of male AGA found that headache was the most frequently reported adverse drug reaction (1.7%), followed by dermatological reactions such as pruritus (1.1%) and rash (1.1%) [14].

A comparison of our findings to the findings of these historic studies reinforces the favorable tolerability profile of topical medications. Altogether, these results demonstrate that the novel compounded formulations of topical finasteride and minoxidil available to male patients with AGA via the Hims & Hers platform are associated with high satisfaction among patients and few reported side effects.

To date, few clinical trials have examined the use of topical finasteride in the treatment of male AGA [10,11,15]. A Phase III RCT by the Topical Finasteride Study Group in Europe found that 41.4% of participants reported treatment-emergent adverse events and 9.9% experienced treatment-related adverse events [10]. Another Phase III RCT in China found that 68.4% of participants reported treatment-emergent adverse events and 8.3% experienced treatment-related adverse events [11]. In both studies, the frequency of adverse events among participants using topical finasteride was similar to those using placebo. A retrospective study of 238 patients who received topical finasteride via a German direct-to-consumer teledermatology platform and completed a 6-week follow-up questionnaire found that 11.8% of patients reported adverse events after initiating the use of topical finasteride [15].

However, the aforementioned studies are methodologically limited by their relatively small sample sizes. This study, which included over 600,000 patients who were prescribed compounded topical finasteride in a real-world context, offers a much more robust and meaningful assessment of patient-reported satisfaction and tolerability associated with treatment.

There are limitations of this analysis. First, this was a retrospective analysis of data collected during the course of routine care and not an RCT, and therefore, we cannot confirm any causal relationships between patients' use of compounded topical finasteride and minoxidil and the reported outcomes. Second, we partly relied on data from an optional follow-up check-in questionnaire sent to patients approximately 130 days after treatment initiation. The rate of check-in completion was relatively low, with 23.7% of patients completing the check-in. This may indicate some selection bias, such that patients who were more engaged in or satisfied with their treatment may have been more likely to respond to the check-in and less likely to report side effects. Patients who reported side effects or other reactions to outside health care providers may not have been captured. Third, our reliance on retrospective data meant that we were unable to systematically examine other data of interest, such as the severity of and types of intervention sought for side effects and other medication reactions reported by patients.

However, our analysis also had several strengths. First, our sample size was impressive, with 638,629 patients prescribed a compounded topical finasteride product, all of whom had the ability to communicate with their care team at any time during the course of treatment, and 151,352 of whom completed the follow-up check-in that specifically queried patients about their experience with treatment and side effects. Second, our analysis utilized real-world data. The use of real-world data enables clinicians and researchers to better understand how patients experience treatment in their daily lives, thus increasing the generalizability of results. Third, in addition to relying on the optional follow-up check-in questionnaire to collect data on patient-reported side effects, we were also able to utilize unsolicited patient communications concerning side effects and other possible medication reactions. Having these additional data increased the likelihood that we were able to capture all occurrences reported by patients.

In conclusion, our analysis found that patients prescribed novel formulations of compounded topical finasteride and minoxidil for the treatment of AGA via a national telehealth platform tolerated the treatment well. The majority reported satisfaction with the treatment, and there were few reports of side effects. Future research should include RCTs to assess the efficacy, safety, and tolerability of topical finasteride. Together, this work may help provide more treatment options for those with AGA.

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Data Availability

The datasets generated or analyzed during this study are not publicly available due to commercial restrictions; however, they may be available from the corresponding author upon reasonable request.

Conflicts of Interest

JY, SM ME, and PC are full-time employees of Hims & Hers Health, Inc. JK and AM serve as advisors to Hims & Hers Health, Inc. Hims & Hers Health, Inc. had no role in the study design, data collection and analysis, decision to publish, or preparation of the manuscript.

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ABBREVIATIONS

AGA: androgenetic alopecia
FDA: Food and Drug Administration
RCT: randomized controlled trial

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Community-Based Teledermatology for Urgent Suspected Skin Cancer: Health Economic Cost-Comparison and Discrete Event Simulation Study

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Abstract

Background: The increasing incidence and financial burden of skin cancer place immense pressure on the UK's National Health Service (NHS). Systemic challenges, including dermatologist shortages and long waiting lists, complicate timely assessment of skin lesions for patients under the urgent suspected cancer pathway. While teledermatology offers an innovative solution compared to traditional face-to-face appointments, standard teledermatology models still face limitations in addressing health care access barriers. Community-based decentralized models may reduce such barriers, but the cost and operational impact of such specific models remain largely underresearched.

Objective: This study evaluated the differences in financial cost to the NHS and patient waiting times at the Northern Care Alliance NHS Foundation Trust by comparing a community-based teledermatology model using Pathpoint eDerma against the Trust's standard-of-care for patients in the urgent suspected skin cancer pathway.

Methods: This study used an ambidirectional design involving 2 distinct analyses. The cost comparison analysis (CCA) compared costs incurred under the teledermatology model (intervention arm, n=563) against the Trust's standard care, represented by a synthetic comparator arm (n=4011). The discrete event simulation (DES) modeled the operational impact on patient waiting times over a 1-year period. Data for the intervention arm were collected prospectively from December 2022 to May 2023 for CCA and up to November 2023 for DES, while comparator data were collected retrospectively from September 2021 to December 2022. Publicly available resource costs were incorporated to ensure the robustness of the analyses.

Results: The community-based teledermatology model was associated with significant improvements in both cost to the NHS and patient waiting times. The CCA revealed a mean cost saving of £45 (£1=US $1.24) per referral (95% CI £22-£60; *P*<.001). This cost saving was associated with a 26% reduction in the proportion of patients requiring a full diagnostic biopsy, falling from 48% (1925/4011) in standard care to 22% (124/563) in the teledermatology model as well as time savings in face-to-face clinics and administration. Furthermore, the DES demonstrated that, on average, the teledermatology pathways decreased the time to reach a clinical diagnosis by 9.90 (95% CI 9.64-10.16) days; to communicate a diagnosis to patients by 54.18 (95% CI 50.76-57.61) days; and to reach a histopathological diagnosis by 62.8 (95% CI 59.76-65.83) days compared to standard care.

Conclusions: The implementation of the community-based teledermatology model appears to be a highly effective, cost-efficient strategy associated with shortened patient journeys. The intervention showed a faster initial triage phase, but the study identified the histopathology process as the next major systemic constraint that could deter further pathway efficiency. Achieving timely diagnosis for all patients, including those requiring diagnostic biopsies, will necessitate continued strategic investment in innovative technologies to accelerate this downstream process.

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KEYWORDS

teledermatology; urgent suspected cancer; cost-effectiveness; discrete event simulation; patient waiting times; community-based; NHS; National Health Service

Introduction

The incidence of skin cancer continues to rise steadily in the United Kingdom. The number of nonmelanoma skin cancer diagnoses surpasses the combined total of the 4 most prevalent nonskin cancers: breast, prostate, lung, and colorectal cancer [1], with malignant melanoma currently listed as the fifth most common cancer [2,3]. The increase in public awareness of skin cancers [4] and the lack of training for general practitioners (GPs) to confidently assess skin lesions [5] have also led to a surge in suspicious skin lesion referrals in the past decade [6]. Skin cancer places a significant financial strain on the National Health Service (NHS), with associated costs in England now projected to reach between £338 million (£1=US $1.24) and £465 million, a significant increase from the previous projection of over £180 million in 2020 [4]. Treatment costs for advanced skin cancer, particularly metastatic melanoma, can be substantial, exceeding £200,000 per case, while early-stage disease has a drastically lower health impact and treatment cost, highlighting the importance of early diagnosis both for the patient and the NHS [7,8].

The rising burden necessitates early detection and management, which, in turn, has placed immense pressure on dermatology services. The NHS is already grappling with significant resource constraints and a national shortage of specialist dermatologists [9]. With almost a quarter of consultant posts unfilled, over 380,000 people are waiting more than 18 weeks for a dermatology appointment [9]. The urgent suspected cancer (USC) pathway aims to provide timely access to care and minimize the risk of cancer progression following initial lesion identification [10]. The aim is achieved by prioritizing patients referred under this pathway to meet the 28-day "Faster Diagnosis Standard" (FDS) [10]; however, national statistics reveal a low conversion rate, indicating that many of these skin lesions are benign [11]. The prioritization of referrals under this pathway has strained resources and subsequently delayed care for patients with other serious, noncancerous conditions like eczema and psoriasis [12].

The systemic challenges have led to the growing adoption of teledermatology as an innovative solution to transform service delivery, although the traditional model of lesion assessment through face-to-face (F2F) clinic appointments remains common [10,13]. Teledermatology is most frequently delivered through a store-and-forward (SAF) model, which involves capturing and transmitting skin lesion images and clinical data on digital platforms for remote assessment by dermatologists [14]. A body of evidence has demonstrated the general effectiveness of this SAF model in addressing workforce constraints, reducing waiting times, and improving patient access [15,16].

However, there are operational limitations reported with the conventional SAF model, specifically within the image capture process [10,13,14,17]. Models relying on image capture performed at the secondary care provider level maintain high image quality but limit efficiency gains by requiring patients to travel to a centralized hospital facility [10,13,14,17]. Conversely, referrer (GP) image capture models often suffer from lower image quality, reduced standardization, and limited uptake due to existing constraints on GP capacity [10,13,14,17]. Consequently, the effectiveness of the traditional SAF model is still limited by existing challenges in health care access, including geographical distance and avoidant behaviors that discourage patients from visiting centralized secondary care facilities [10,13,14,17]. Single-site SAF models in particular are also limited in their ability to support regional strategic plans that seek to pool resources and support smaller sites.

To mitigate the challenges inherent in conventional teledermatology, we implemented a community-based teledermatology model, using the Pathpoint eDerma digital platform (Open Medical Ltd). This model was specifically designed to ensure high-quality image capture delivered by a dedicated health care assistant while providing timely and accessible care closer to patients' homes. This approach aligns directly with the NHS's strategic vision to shift "from hospital to community," thereby improving access, quality, standardization, and uptake of the teledermatology service [18]. The platform's data architecture and integration capabilities are also future-proofed to support delivery of more comprehensive regional care models [19].

Currently, the literature lacks a robust, real-world evaluation of a community-based model within the urgent suspected skin cancer pathway in the NHS. This study sought to address this gap by providing a comprehensive analysis of the cost implications and operational efficiency of the community-based teledermatology model from a health care system standpoint. In this study, we compare a community-based teledermatology model using Pathpoint eDerma against the trust's standard of care for patients in the urgent suspected skin cancer pathway to evaluate the associated cost implications for the Northern Care Alliance NHS Foundation Trust (NCAFT) and patients' waiting times.

Methods

Study Setting

The study was conducted within the dermatology department at NCAFT. This trust is one of the largest NHS providers in the country, which delivers health care to over 1 million people across Salford, Oldham, Rochdale, and Bury [20]. As part of a wider teledermatology project launched in December 2022, NCAFT established its first community-based teledermatology service. This model used a community diagnostic center (CDC) in Bury, allowing patients to have their skin lesions photographed closer to home rather than at the traditional location, Salford Royal Hospital. The study population included patients referred by their GPs to the urgent suspected skin cancer pathway (formerly known as the 2-week wait [2WW]), who presented with 2 or fewer suspicious lesions.

Study Design

This study used a comparative, ambidirectional design to evaluate a teledermatology model against local standard care. It consisted of 2 distinct analyses: a cost comparison analysis (CCA) to evaluate the budgetary implications for the NHS trust and a discrete event simulation (DES) to model the differences in patient waiting times. The study is considered ambidirectional

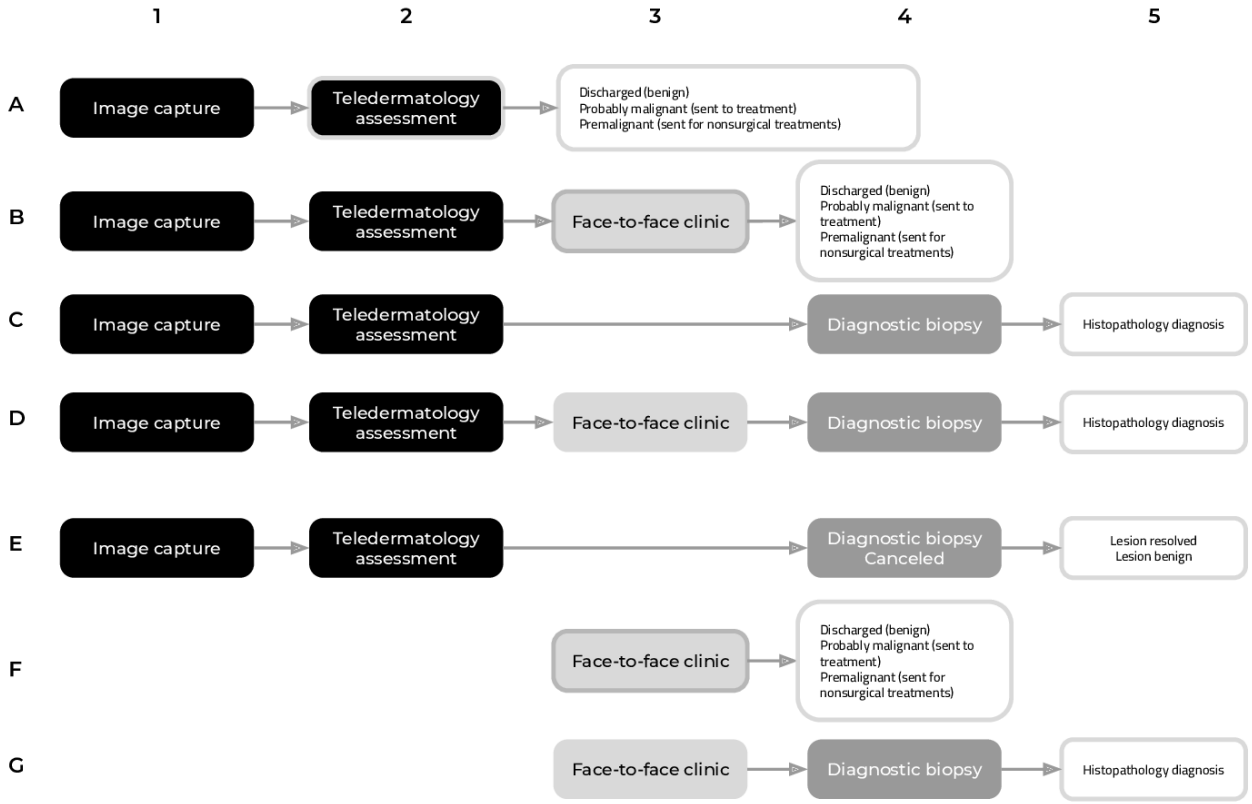
as data for the intervention arm were collected prospectively, while data for the comparator arm were collected retrospectively from historical records. Different time horizons were used in the analyses and are detailed in the data collection section.

Intervention and Comparator Arms

Each arm of the study comprised several distinct pathways representing the patient journey from referral to diagnosis. Under the intervention arm, a patient's journey began with an image capture appointment at the CDC. There, a trained health care assistant captured high-quality macroscopic and dermatoscopic images of the lesion(s) and uploaded them, along with referral notes and a digitally completed patient questionnaire, to the eDerma platform. A consultant dermatologist then remotely reviewed this information to determine the clinical outcome. This process defined 5 distinct intervention pathways (A-E).

In contrast, the comparator arm reflected the local standard-of-care pathways (F and G), where patients attended a F2F clinical appointment with a consultant dermatologist for an in-person dermoscopic examination. Following this consultation, the patient was either discharged (pathway F) or scheduled for a diagnostic biopsy (pathway G). The outcome of a canceled diagnostic biopsy (pathway E) is also a potential event for patients following the standard-of-care F2F pathway, though less frequent and was not observed in the dataset used for this study (Figure 1).

Figure 1. Potential pathways under the intervention and comparator arms.



Data Collection

For the CCA, prospective data for the teledermatology model's intervention arm were sourced from the Pathpoint eDerma platform, spanning from December 2022 to May 2023. Conversely, retrospective data for the standard care comparator arm were collected from historical NCAFT records from September 2021 to December 2022 and supplemented with public NHS protocols. This process created a synthetic control group for the comparator arm, enabling a direct cost comparison between the 2 pathways. Due to the historical nature of the records, this cohort was reconstructed using a triangulated audit approach. A manual review of 70 F2F clinical cases was conducted to determine granular pathway distributions (F and G), which were then calibrated against a larger trust-level dataset of over 5000 urgent referrals to establish representative waiting times. The comparator arm's period was also chosen to ensure it reflected a post-lockdown health care environment. National NHS data indicated that by late 2021, USC referrals for skin lesions had returned to, or exceeded, prepandemic volumes [21]. Consequently, the analysis assumes that patient reluctance to seek treatment was not a significant factor in the diagnostic timelines observed during the comparator period. Additionally, we included resource utilization data, such as staff labor and procedure costs (eg, diagnostic biopsies), which were adjusted to 2023 values for inflation using the Personal Social Services Research Unit manual [22] and the NHS National Cost Collection schedule [23].

The same retrospective data were then repurposed for the DES to inform the operational parameters of the "as-is" model, effectively defining the simulation's structure and serving as the baseline for comparison. To increase the real-world accuracy of the simulation, we integrated additional data to define specific

parameters. These included patient pathway proportions and communication methods from the eDerma platform, patient inflow rates from NHS England's Cancer Waiting Times Statistics [21], and staff numbers estimated from NHS Hospital & Community Health Service monthly workforce statistics [24]. The simulation of the intervention arm was further strengthened by incorporating an additional 6 months of prospective data, extending its data collection period up to November 2023.

Statistical Analyses

To ensure the study's independence and meet the requirements of the teledermatology project's funders, the CCA and DES were conducted by an external health technology consultancy, Health Tech Enterprise. Although the analyses were performed independently, the authors of this study provided the necessary datasets and contextual information. They also reviewed the methodology to ensure it accurately reflected the specific teledermatology project under evaluation.

The health economic CCA compared and quantified the budgetary impact of the teledermatology model against standard care from the perspective of the NHS. The analysis focused on direct medical costs incurred from the point of referral to the point of diagnosis, including health care staff labor (Bands 3, 5, 9, and Consultant levels), diagnostic biopsy procedures, and technology platform licensing. A health economic model was constructed in Microsoft Excel (Microsoft 365, v2310; Microsoft Corp) to determine the average cost per referral for both the intervention and comparator arms. This was followed by an incremental analysis to account for the SEs associated with health care staff involvement.

To test whether the difference in mean costs was statistically significant, an unpaired *t* test was performed. Further, we conducted a probability sensitivity analysis with 1000 model iterations and a deterministic sensitivity analysis to account for uncertainty in input parameters and evaluate how changes in key parameters, such as the number of biopsies, affected the results.

Moreover, we performed a DES to evaluate the impact on patient waiting times. The skin cancer screening pathways were modeled as an agent-based DES using SIMUL8 software (Professional Edition) over a 1-year time horizon. The model's capacity was based on the availability of health care staff and accounted for the seasonality of patient inflow. The simulation was run for five 1-year instances, with each patient "agent" entering the model upon referral and exiting once a diagnosis was communicated.

The simulation measured 3 key end points, representing different waiting periods: the average time from referral to clinical diagnosis, the average time from referral to histopathological diagnosis (for patients requiring a diagnostic biopsy), and the average time to final diagnosis communication.

Model Assumptions

The CCA was built upon several assumptions regarding patient characteristics and resource utilization to enable a direct cost comparison between the intervention and comparator pathways. It was assumed that patient characteristics were the same in both the intervention and comparator arms. For the standard-of-care (comparator) arm, all consultations were modeled as F2F. Specific durations were assigned to clinical activities; the initial F2F consultation with a consultant dermatologist was set at 20 minutes, while a follow-up clinic appointment after the eDerma assessment was set at 15 minutes. The resource cost model assumed that a photography appointment, conducted by an NHS Band 3 health care assistant at a local GP practice, took 20 minutes, and the remote eDerma assessment by a consultant dermatologist took approximately 4.97 minutes. Furthermore, it was assumed that any dermoscopy examination performed in the comparator arm was included within the F2F consultation time, eliminating the need for an additional photography assessment.

Similarly, the DES relied on several assumptions to model patient flow and system capacity under controlled conditions. The simulation modeled high-risk patients referred via the 2WW pathway with 2 or fewer lesions, reflecting current clinical practice and ensuring a realistic assessment of the current adoption of eDerma technology in the health care setting. This approach provides a baseline understanding of the technology's impact under current conditions and practices.

The simulation also assumed 100% patient retention (no dropouts) and no patient "no shows" for F2F appointments. The model also excluded patient mortality. Operational capacity was modeled based solely on health care staff availability, assuming fixed staffing levels throughout the simulation and excluding equipment or facility constraints. Furthermore, labor was scheduled with staff available on weekdays (8:30 AM to 6:30 PM) and 70% of staff available for reduced weekend shifts, with the exception of GP. Procedures were allocated based on a simplified first-come, first-served basis and patient risk level, disregarding individual patient availability.

Ethical Consideration

The study used anonymized standard care data. The project was reviewed by the NCAFT Research and Innovation Department (22HIP55) and was determined not to require further ethical review. Specifically, the project was registered as a Health Improvement Project (22HIP55) and was determined by the Research and Innovation office not to require NHS Health Research Authority review. This determination was made in accordance with national regulations, including the Data Protection Act [25], the General Data Protection Regulation [26], and applicable Health Research Authority [27] guidance. As this was a retrospective study using anonymized routinely collected data, the requirement for formal informed consent was not required, as confirmed by the NCA Research and Innovation department. For the Patient-Reported Experience Measure surveys, patients were informed of the evaluation's purpose, and participation was entirely voluntary. No compensation or financial incentives were provided to the patients participating in the surveys. To ensure patient privacy, all data were deidentified before being used for analysis under the formal Data Sharing and Processing Agreements. Furthermore, all researchers were issued formal Letters of Access mandating strict adherence to the trust's information governance and

confidentiality policies, and all methods in this study adhered to the ethical principles outlined in the Declaration of Helsinki.

Results

Description of Dataset

This study's dataset included 563 urgent skin lesion referrals (so-called "2WW" referrals) managed via the intervention arm. A synthetic comparator arm of 4011 referrals was generated based on referral-to-diagnosis times from 2 years of urgent skin cancer referrals (>5000 cases), supplemented with more granular information regarding the methods of diagnosis (F and G in Figure 1) that were available from 70 cases. The same data distributions were subsequently used to conduct the DES.

Within the intervention arm cohort, 324 out of 563 (57.5%) were female participants, and this cohort had a mean age of 61.5 (SD 17.6) years at the time of referral (Table 1), consistent with the higher risk of skin cancer in older populations resulting from accumulated, lifelong UV exposure [1,4,10]. While granular demographic data for the synthetic comparator arm were unavailable, clinical comparability between the 2 arms was maintained by ensuring that both cohorts consisted of adult patients referred via the USC pathway, presenting with 2 or fewer suspicious lesions at the trust. Furthermore, a parallel health inequality assessment, conducted independently of the CCA and DES but within the same trust and clinical pathway, confirmed that the local patient population remains sociodemographically consistent. The NCA cohort typically reflects a more socioeconomically advantaged profile, with a median Index of Multiple Deprivation decile of 6 (IQR 3-8) and a mode of 8.

Table . Sociodemographic and clinical characteristics of the intervention arm (N=563).

Characteristic	Value
Sex, n (%)	
Female	324 (57.5)
Male	239 (42.5)
Age (y), mean (SD)	61.5 (17.6)
Referral pathway	Urgent suspected cancer with 2 or fewer suspicious lesions

Cost Comparison Analysis

The analysis demonstrates substantial cost savings for the NCAFT through the implementation of the community-based teledermatology model compared to standard care (Table 2). The probability sensitivity analysis showed a mean savings of £45 (95% CI £22-£60) per referral with the eDerma model. This translates to a potential overall savings of £25,251 (95% CI £12,462-£34,002) for the NCAFT from December 2022 to May 2023. An unpaired *t* test confirmed that the difference in mean costs between the 2 arms was statistically significant (P<.001). Based on 1000 iterations, a cost reduction per referral was observed in 94% of cases.

A subanalysis further revealed the mechanism behind these savings by assessing the distribution of referrals and their associated unit costs (Table 3). The highest costs were incurred in pathways involving a full diagnostic biopsy, specifically pathways C, D, and G. The community-based eDerma model led to an 18% reduction in referrals needing a biopsy, as the percentage of patients in biopsy-reliant pathways fell from 49% (1965/4011) in the comparator arm (pathway G) to 31% (175/563) in the intervention arm (pathways C and D combined). A 1-way deterministic sensitivity analysis supported this finding by showing that if the eDerma system could offset the need for full biopsies, it could lead to a mean cost savings of up to £135 per referral.

Table . Potential cost savings via the eDerma intervention arm.

Economic parameter	Cost savings[a] (comparator arm–eDerma)	95% CI
Potential cost savings per referral	£45	£22-£60
Potential overall cost savings	£25,251	£12,462-£34,002

[a]£1=US $1.24.

Table . Referral percentage and unit costs in each pathway.

Arms and associated pathways	Referral percentage (%)	Unit cost (£)[a]
Intervention arm (eDerma)		
A	44	55
B	21	219
C	17	371
D	14	542
E	3	137
Comparator arm (standard-of-care)		
F	51	163
G	49	364

[a]£1=US $1.24.

Discrete Event Simulation

The DES used a slightly different pathway distribution due to the additional 6 months data for the intervention arm. The simulation demonstrated a similar and even more pronounced effect, with the biopsy rate falling from 48% (1925/4011) (pathway G) in standard care to 22% (pathway C and D) in the teledermatology model (Table 4).

Table . Pathway distribution used in the discrete event simulation.

Arms and associated pathways	Referral percentage (%)
Intervention arm	
A	53
B	24
C	5
D	17
E	1
Comparator arm	
F	52
G	48

Referral to Diagnosis Communication

To determine the overall average waiting times for the eDerma and standard-of-care arms, a weighted average was calculated by combining the average time for each pathway (A-E in the intervention arm vs F and G in the comparator arm) with the proportion of patients using each communication method. Finally, an incremental analysis was performed to compare the average waiting times of the 2 arms.

The methods of diagnosis communication included letters, emails via the eDerma platform, telephone calls, and F2F appointments. Complete results on the average time for each communication method and the weighted average of each pathway are detailed in Multimedia Appendix 1.

The analysis of weighted average times per pathway reveals that pathway A in the intervention arm has the shortest average time from referral to diagnosis communication, at 8 days. In contrast, the pathways involving diagnostic biopsies, pathways C and D from the intervention arm and pathway G from the comparator arm, show substantially longer weighted average times of 52.4 and 131.1 days, respectively.

The overall weighted average time for the intervention arm was 18.97 (SE 0.92) days. Conversely, the standard care arm had a weighted average time of 73.16 (SE 1.48) days, illustrating a more extended duration (Table 5).

Table . Comparison of the overall weighted average time from referral to diagnosis communication.

Referral to diagnosis (d)	Intervention arm	Comparator arm
Weighted average time	18.97	73.16
Weighted standard error	0.92	1.48
Maximum time	109.5	252.3

Referral to Clinical Diagnosis

The DES analysis demonstrated that the eDerma arm reached clinical diagnosis faster, with a mean of 7.38 (95% CI 7.24-7.52) days from the initial referral. In the comparator arm, the mean time to clinical diagnosis was longer, at 17.29 (95% CI 17.07-17.50) days.

Referral to Histopathological Diagnosis

For patients undergoing a biopsy, the histopathological diagnosis occurred, on average, within 66.42 (95% CI 65.33-67.50) days in the eDerma arm (Table 6). This was significantly shorter than the comparator arm, where the average waiting period for a histopathological diagnosis was 129.21 (95% CI 126.38-132.05) days (Table 6).

A subsequent incremental analysis highlighted the impact of the community-based teledermatology model in reducing patients' waiting times. On average, the teledermatology pathways were associated with a decrease in the time required to establish and communicate a skin cancer diagnosis to a patient by 54.18 (95% CI 50.76 to 57.61) days. Furthermore, the average waiting time for a clinical diagnosis and histopathological diagnosis was reduced by 9.90 (95% CI 9.64-10.16) days and 62.80 (95% CI 59.76-65.83) days, respectively. These findings are summarized in Table 7.

Table . Comparison of referral to clinical diagnosis and referral to histopathological diagnosis results.

Parameter	Intervention arm (teledermatology model)	Comparator arm (standard care)
Referral to clinical diagnosis (d)		
Mean (SE)	7.38 (0.07)	17.29 (0.11)
95% CI	7.24-7.52	17.07-17.50
Max	31.67	50.28
Referral to histopathological diagnosis (d)		
Mean (SE)	66.42 (0.55)	129.21 (1.45)
95% CI	65.33-67.50	126.38-132.05
Max	109.41	248.37

Table . Summary of discrete event simulation analysis.

Incremental analysis Δ (waiting time in current care–waiting time in eDerma care)	Mean (95% CI)
Average time to diagnosis communication (d)	54.18 (50.76-57.61)
Average time to clinical diagnosis (d)	9.90 (9.64-10.16)
Average time to histopathological diagnosis (d)	62.80 (59.76-65.83)

Discussion

Principal Findings

The study demonstrated that the community-based teledermatology model, facilitated by Pathpoint eDerma, was associated with significant cost savings of £45 per referral and a 54.18-day reduction in diagnosis communication. This efficiency is driven by the operational shift from a centralized secondary care workflow to a decentralized, community-level approach. By moving imaging to local CDCs, the model effectively diverted referrals away from hospital-based bottlenecks and addressed the "upstream" consultant-capacity shortages, allowing dermatologists to triage cases remotely.

Another driver of these efficiencies was the 26% reduction in the proportion of patients requiring biopsy-reliant pathways, falling from 48% (1925/4011) in standard care to 22% (124/563) in the teledermatology model. The analysis demonstrates that diagnostic biopsies are the most expensive and resource-intensive stage of the urgent skin cancer journey. By facilitating definitive clinical triage through high-quality imaging, the teledermatology model minimizes unnecessary surgical interventions, potentially leading to cost savings of up to £135 per referral when biopsies are offset.

The model successfully mitigates the initial bottleneck associated with consultant capacity, effectively managing high referral volumes. Our DES highlighted that this upstream optimization has, in turn, revealed a downstream constraint within the histopathology service. The massive disparity in waiting times between pathways requiring a biopsy and those that do not highlights a critical resource limitation at the histopathology level. This constraint now represents the primary rate-limiting step impacting referral-to-diagnosis time. Therefore, to realize further gains in operational efficiency and to ensure that the 28-day FDS is consistently achieved, future service improvement initiatives should be directed toward optimizing the capacity and workflow of the histopathology reporting pathway.

Operational solutions, such as the outsourcing of histopathology services, are currently performed in NCAFT following the completion of this study to increase reporting capacity. Looking forward, this constraint could also potentially be resolved through the adoption of technologies like digital and computational pathology [28,29]. Digital pathology (eg, whole

slide imaging) can enable remote review by pathologists [28]. Alternatively, computational pathology, including artificial intelligence, could accelerate diagnostic throughput by providing intelligent triage to prioritize high-risk cases and automated quantification to speed up time-intensive tasks like measuring tumor margins [29].

Policy Implications

The success of this model has significant implications for NHS health system planning. The findings support the NHS England Teledermatology Roadmap [10] by demonstrating that decentralized models can successfully achieve national targets that remain elusive under traditional F2F care. For these models to be scalable, future policies must prioritize high standards of digital interoperability where platforms can securely span the entire referral journey, enabling swift information sharing between GP, patients, and secondary care providers. Furthermore, the transition "from hospital to community" aligns with the NHS 10-year vision [18], suggesting that future capital investment should be directed toward community imaging infrastructure to sustain these efficiency gains.

Limitations and Recommendations

As an ambidirectional study, the use of nonoverlapping time horizons between the study arms introduces a potential risk of temporal confounding. Observed improvements in wait times and biopsy rates may have been partially influenced by systemic shifts in NHS dermatology protocols following the October 2022 guidelines. Nonetheless, it is essential to distinguish between the national mandate provided by these guidelines and the operational execution enabled by the intervention. Although the guidelines formalize the 28-day FDS, national dermatology waiting lists have remained at historic highs due to chronic consultant shortages [9]. Furthermore, national data indicate that by late 2021, USC referrals had already reached record-high volumes [21], suggesting that the comparator period (September 2021 to December 2022) represents a stable baseline of high systemic operational pressure. The 54.18-day reduction in diagnosis communication suggests an operational impact that far exceeds typical year-on-year service fluctuations, indicating that the digital model addressed these persistent pressures more effectively than the traditional F2F standard of care.

Another methodological limitation was the exclusion of false-negative rates and their associated long-term treatment costs from the economic model. While a longitudinal follow-up for this specific cohort was not feasible, SAF teledermatology possessed an established safety profile in clinical literature, demonstrating diagnostic accuracy and sensitivity comparable to traditional F2F triage [10,14,15,30]. To ensure a transparent and unbiased economic evaluation, these potential downstream costs were excluded consistently across both study arms. Consequently, the reported £45 mean cost saving represents a conservative estimate of the direct, front-end budgetary impact on the trust.

The DES relied on approximations for parameters such as histopathological processing times and professional review durations, which may not perfectly mirror real-world variability. Additionally, the simulation did not account for missed appointments or fluctuating staff availability, and the single-site nature of the study may limit the immediate generalizability of these findings to other regions. To address these constraints, future research could use multisite longitudinal designs, such as randomized stepped-wedge trials, to assess the long-term sustainability of these cost savings. Given that various teledermatology models are already deployed across the United Kingdom, a collaborative effort to prospectively collect standardized data for comparative health economic evaluations may represent the most pragmatic next step.

Furthermore, the use of a F2F clinic as the comparator, as opposed to a direct comparison with a traditional single-site SAF teledermatology service, was a deliberate choice to evaluate the model against current local standards. It is crucial to note that the community-based model offers inherent strategic advantages not captured by wait-time and financial metrics alone, such as improved patient access [12], reduced patient costs [31], and its unique suitability for deploying region-wide collaborative care networks that single-site models may struggle to support.

From a clinical perspective, this study focused on patients in the USC pathway with 2 or fewer suspicious lesions, a cohort primarily consisting of benign cases or early-stage malignancies. While this pathway is key for early detection, individuals with late-stage skin cancer are less likely to access care through this specific route. Therefore, further research is required to understand the journeys of patients with advanced disease to identify unique barriers and develop targeted interventions for timely access.

Ultimately, the community-based teledermatology model was developed to resolve NHS dermatology capacity constraints and to serve as a robust mitigation strategy for traditional access barriers. While the primary focus of this study was on the budgetary and operational implications, findings from a parallel Health Inequality Assessment at the same trust confirmed that diagnostic timelines remained equitable across all age and deprivation groups within this model. This suggests that decentralizing care to local CDCs mitigates the travel and mobility burdens that traditionally hinder older populations at higher risk of skin cancer [1,4,10] and those from more deprived socioeconomic backgrounds [31].

Conclusion

Our results suggest that a community-based teledermatology model, using the Pathpoint eDerma platform, can provide an efficient and cost-effective pathway for urgent suspected skin cancer referrals, benefiting both the health care system and patients. By being associated with a 26% reduction in biopsy-reliant pathways and an observed 54.18-day reduction in communication times, the model offers a viable strategy to address critical resource constraints within the NHS. Future practical interventions should focus on expanding community-based imaging infrastructure to reduce travel burdens for high-risk older populations, while exploring the potential of digital pathology and other operational solutions to resolve the remaining downstream bottlenecks identified in this analysis.

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Data Availability

The datasets used and analyzed for the current study, along with the full discrete event simulation report that includes additional subanalyses, are available from the corresponding author upon reasonable request.

Authors' Contributions

TCHH conceptualized the study in partnership with Health Tech Enterprise and the Patient and Public Involvement and Engagement committee, collected and prepared datasets for analysis, reviewed the methodology and results, and contributed to the manuscript's write-up. NAN performed a comprehensive literature review, prepared the original manuscript, and was responsible for continuous refinement of the manuscript up to the point of publication. PGM reviewed the manuscript draft, offered practical insights into the functioning of the dermatology department at the trust, and potential external influences. PM obtained study funding. All authors have critically reviewed and accepted the final format of the manuscript.

Conflicts of Interest

Authors NAN, TCHH, and PM declare a competing interest in their employment by Open Medical Ltd.

Multimedia Appendix 1
Average time from referral to diagnosis per communication methods and weighted average time per pathway.
[PDF File, 85 KB - derma_v9i1e86402_app1.pdf]

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Abbreviations

CCA: cost comparison analysis

CDC: community diagnostic center
DES: discrete event simulation
F2F: face-to-face
FDS: Faster Diagnosis Standard
GP: general practitioner
NCAFT: Northern Care Alliance NHS Foundation Trust
NHS: National Health Service
SAF: store-and-forward
USC: urgent suspected cancer

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Identifying Over- and Underfunded Diseases by Comparing National Institutes of Health Funding for Skin Disease Research With US Skin Disease Burden According to 2021 Global Burden of Disease Data: Cross-Sectional Analysis

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Abstract

Background: Understanding the burden of various skin diseases can help guide funding allocation for skin disease research. A 2015 cross-sectional study found a partial correlation between US skin disease burden according to the 2010 Global Burden of Disease (GBD) study and National Institutes of Health (NIH) funding in 2012-2013.

Objective: This study aims to identify trends, correlations, and disparities in US skin disease burden and NIH research funding allocation using the latest data from the GBD 2021 and NIH funding data from the fiscal years 2021-2022.

Methods: A cross-sectional analysis was conducted to compare the disability-adjusted life years for 15 skin conditions from the GBD 2021 with NIH funding for these conditions in 2021-2022. Data were sourced from the GBD Results tool and the NIH RePORTER database.

Results: NIH funding for skin disease research and US skin disease burden according to the GBD 2021 were partially correlated, with several outliers. Malignant skin melanoma and pruritus were relatively overfunded, while psoriasis and urticaria were relatively underfunded.

Conclusions: Disease burden is just one of the many important factors that must be considered when allocating resources, including funding to encourage research efforts to improve patient outcomes and positively impact public health.

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KEYWORDS

epidemiology; burden of disease; disability-adjusted life years; research funding; melanoma; psoriasis; dermatitis

Introduction

The Global Burden of Disease (GBD) study aims to quantify worldwide health losses due to a wide variety of illnesses and injuries [1]. Disease burden is one of many important factors guiding decisions on policy development, disease prevention initiatives, and research funding allocation [1,2]. The GBD study quantifies disease burden using disability-adjusted life years (DALYs), a measure that accounts for both mortality due to disease (years of life lost) and years lived with decreased health and quality of life (years lived with disability; YLDs) [1]. GBD also accounts for the severity of disability (defined by any short-term or long-term loss of health) attributed to the variety of illnesses and injuries included in the study by factoring disability weights into the calculation of YLDs [1,3].

Skin conditions are ubiquitous worldwide and affect millions each year. As a result, dermatology continues to be a consistently innovative field that makes large strides in patient care thanks to a heavy research focus. Public funding is a major contributor to research and innovation in this field. In 2015, Hagstrom and colleagues [4] conducted a cross-sectional study that found a partial correlation between US skin disease burden according to the GBD 2010 and National Institutes of Health (NIH) funding in the fiscal years 2012 - 2013, identifying over- and underfunded diseases. Following this study, there have been major changes to the funding of dermatology research, with a 14.7% inflation-adjusted increase in research funding from 2015 to 2019 and fluctuations in funding after the COVID-19 pandemic [5,6]. This study reinvestigates the relationship between US skin disease burden using the latest GBD 2021 data and NIH funding data for 2021 - 2022.

Methods

Overview

A cross-sectional analysis was conducted to compare DALYs for the 15 skin conditions included in the GBD 2021 with NIH funding for these conditions in 2021 - 2022. Data were sourced from the GBD Results tool [1] and the NIH RePORTER database [7]. The search parameters used in GBD Results to obtain DALY metrics for all 15 aforementioned skin disease categories in the US were as follows: measure="DALYs," metric="number," location="United States of America," age="all ages," sex="both," and year="2021." DALY metrics were specifically gathered for the United States to facilitate a direct comparison between the US-specific burden of skin diseases measured by DALYs and funding allocated by the NIH in the United States for skin disease research.

To compile a comprehensive list of NIH-funded grants awarded for skin disease research during fiscal years 2021-2022, a total of 15 queries were entered into the NIH RePORTER database, with each query corresponding to one of the GBD skin disease categories. The following parameters were used to conduct all 15 of these search queries: fiscal year="2021 and 2022," text search logic="advanced," and limit project search="project title, project terms, and project abstracts." In the Text Search box, all *International Classification of Diseases, 10th Revision* codes categorized by the GBD 2021 under one specific skin disease category were strung with "AND," "OR," or "NOT" as determined necessary to capture all relevant NIH-funded grants.

All titles and abstracts of the grants obtained from NIH RePORTER were manually screened by two independent reviewers to determine inclusion versus exclusion (they were included if the grant studied any 1 of the 15 skin disease categories described by the GBD 2021). Following independent review, inclusion and exclusion decisions were cross-examined to identify conflicting decisions. A third reviewer served as a tie-breaker to resolve any discrepancies as needed.

Statistical analysis was performed assuming that the proportion of DALYs attributed to a disease should be the same as the proportion of NIH skin disease funding it receives (ie, if a specific disease is responsible for 25% of all US skin disease DALYs, that disease should receive 25% of all NIH skin disease funding). A one-to-one trendline was used to visualize this relationship and identify outliers representing relatively over- and underfunded skin diseases. An "observed-to-expected" ratio was calculated by dividing the true amount of funding a disease received by the amount of funding a disease could be expected to receive assuming a one-to-one relationship between DALYs and funding.

Ethical Considerations

This study was exempt from review by the institutional review board, and no patient or participant consent was required or obtained, as this study did not constitute human subjects research and used publicly available data.

Results

Our analysis revealed a positive correlation between the percentage of total US skin disease DALYs in 2021 and the percentage of total NIH skin disease funding in 2021 - 2022. The correlation coefficient between these two data points was 0.3167 (95% CI 0.053626-0.579774). There were several key outliers when comparing DALYs to funding, indicating that certain skin diseases were relatively over- or underfunded in comparison to their proportion of total disease burden. Pruritus and malignant melanoma received 445% and 392% of the proportion of funding expected by their proportion of DALYs (Table 1). Other relatively overfunded diseases include leprosy, decubitus ulcers, bacterial skin diseases, and nonmelanoma skin cancer (Figure 1, Table 1).

Figure 1. Scatterplot comparing proportion of National Institutes of Health (NIH) skin disease funding received in 2021 - 2022 with the proportion of total US skin disease disability-adjusted life years (DALYs) according to the 2021 Global Burden of Disease study.

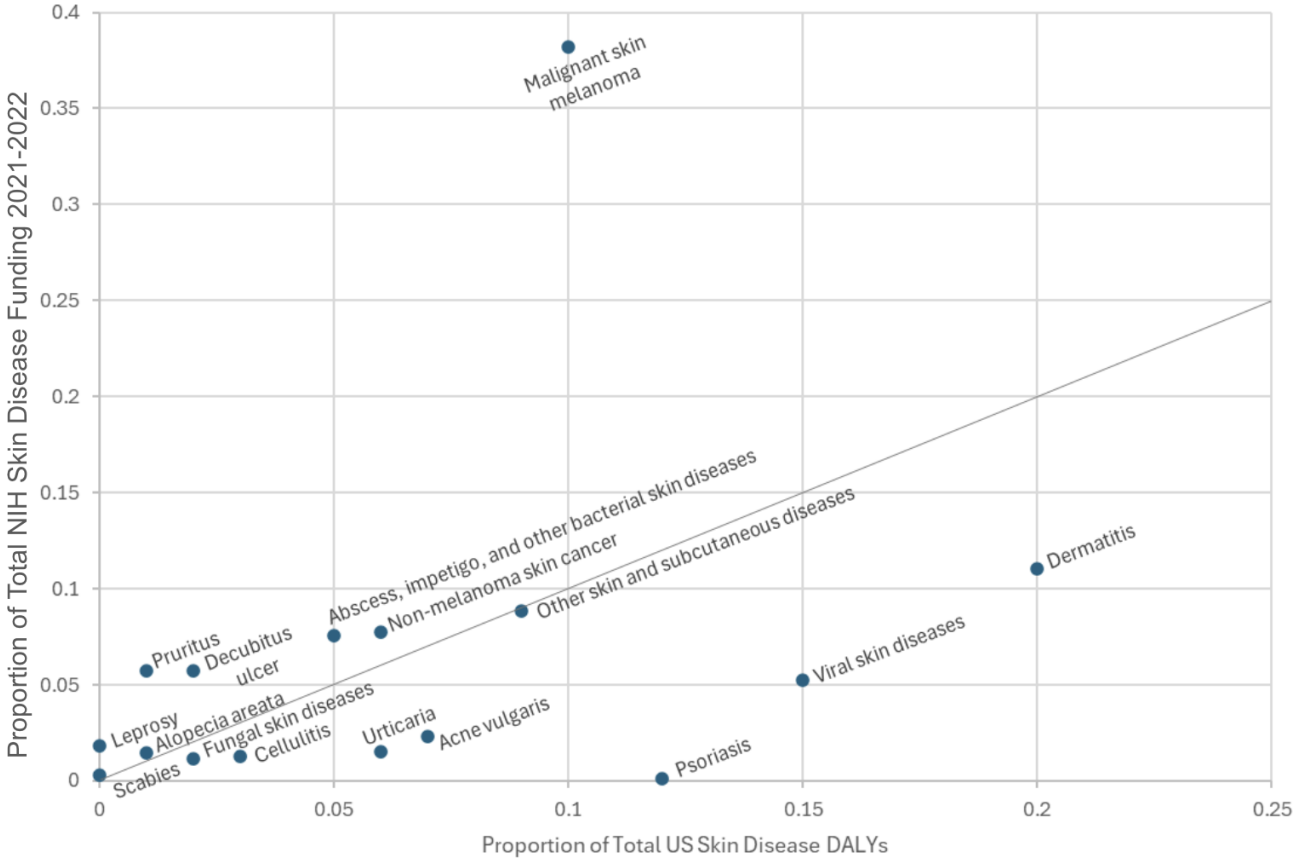

Table . Comparison of disability-adjusted life year (DALY) rank from Global Burden of Disease GBD 2010 and 2021 study data, comparison of National Institutes of Health (NIH) funding in fiscal years 2012 - 2013 (data from Hagstrom et al [4]) and 2021-2022 (data from the current analysis), and the percentage of total US skin DALYs (in 2021) and NIH skin disease funding (in 2021 - 22).

Category	US DALY rank in 2021	Proportion of total US skin disease DALYs in 2021, %	US DALY rank in 2010[a]	NIH funding rank in 2021 - 2022	Proportion of total NIH skin disease funding in 2021 - 2022, %	NIH funding rank in 2012 - 2013[a]	Observed-to-expected ratio for funding[b]
Pruritus	13	1.29	5	6	5.74	6	4.45
Malignant skin melanoma	4	9.75	3	1	38.19	1	3.92
Decubitus ulcer	11	1.87	8	7	5.74	11	3.07
Abscess, impetigo, and other bacterial skin diseases	8	4.90	13	5	7.56	9	1.54
Nonmelanoma skin cancer	6	6.10	2	4	7.73	2	1.27
Alopecia areata	12	1.36	11	12	1.48	13	1.09
Other skin and subcutaneous diseases	—[c]	9.30	—	3	8.87	3	0.95
Scabies	14	0.38	14	15	0.30	16	0.8
Dermatitis	1	19.98	1	2	11.03	5	0.55
Fungal skin diseases	10	2.17	9	14	1.14	10	0.53
Cellulitis	9	3.42	12	13	1.26	12	0.37
Viral skin diseases	2	14.61	6	8	5.22	4	0.36
Acne vulgaris	5	6.99	4	9	2.29	14	0.33
Urticaria	7	5.80	7	11	1.51	15	0.26
Psoriasis	3	12.10	10	16	0.09	7	0.0082
Leprosy[d]	15	0	15	10	1.84	8	—[d]

[a]Data obtained from Hagstrom et al [4].

[b]Percentage of funding vs percentage of DALYs.

[c]Not applicable.

[d]Ratio of funding proportion to DALY proportion could not be calculated for leprosy, as the proportion of DALYs for leprosy was 0.

Conversely, psoriasis, fungal skin diseases, cellulitis, urticaria, acne vulgaris, viral skin diseases, and dermatitis were underfunded. Notably, psoriasis received only 0.82% of the funding expected by its disease burden (Table 1). Funding for scabies, alopecia areata, and the "other skin/subcutaneous diseases" category appeared well matched to their disease burden, receiving between 80% to 110% of the funding predicted by their respective DALYs (Figure 1, Table 1).

Discussion

Principal Findings

This study reinvestigated the relationship between US skin disease burden and NIH skin disease research funding using the latest GBD 2021 data and NIH funding data from fiscal years 2021 - 2022. Compared to Hagstrom et al's [4] 2015 study, many of the same trends in relative over- and underfunding of skin diseases were observed. For example, malignant melanoma remains the most significantly overfunded skin disease relative to its disease burden (Table 1) [4]. Nonmelanoma skin cancer and leprosy also remain overfunded, while dermatitis, acne vulgaris, urticaria, fungal skin diseases, and cellulitis remain underfunded (Table 1) [4]. Interestingly, pruritus and decubitus ulcers, previously underfunded in 2015, now appear to be relatively overfunded (Table 1) [4]. Funding for psoriasis was well matched to its disease burden in 2015, but in our updated analysis, psoriasis is the most underfunded skin disease category. Similarly, viral skin diseases were well funded in 2015 and now appear underfunded (Table 1) [4].

It is important to consider disease burden when allocating research funding to ensure adequate resources are being directed toward diseases with the most significant impact. Dedicating more resources toward high-burden diseases can improve individual health and quality of life by driving the development

of innovative treatments and can also provide long-term economic benefits by reducing health care costs and increasing overall workforce productivity.

In addition to disease burden, many other factors also significantly impact resource prioritization and funding allocation. For example, more research funding is likely to be allocated to diseases with strong public awareness and advocacy campaigns, such as malignant skin melanoma. Funding is also likely influenced by disease curability and the potential for therapeutic innovation. The NIH may also prioritize funding for diseases with lower incidence or prevalence but higher mortality (ie, metastatic melanoma, metastatic nonmelanoma skin cancer) rather than diseases with lower mortality but higher incidence or prevalence (ie, dermatitis and acne vulgaris).

Limitations

It is important to keep in mind that using data strictly from the GBD study and the NIH does not fully capture all of the nuances of US skin disease burden and research funding. An important limitation of this analysis, similar to Hagstrom et al's [4] prior study, is the exclusion of industry research funding by pharmaceutical companies and other nongovernmental entities from NIH funding data [4,7]. The NIH is the largest source of public funding for biomedical research; however, a significant portion of research funding also comes from nonprofits, philanthropic organizations, and private industry [8]. Therefore, while a disease may appear underfunded relative to its disease burden using GBD and NIH data alone, additional research funding from nongovernmental agencies may be filling this perceived gap in resource allocation. For instance, although our analysis showed that psoriasis received significantly less funding from the NIH relative to its disease burden, substantial funding from pharmaceutical companies has driven the development of innovative new drugs (ie, IL-23 and IL-17 inhibitors) that have transformed the treatment of psoriasis in recent years [9]. Similarly, previous reviews have cited US $22,291,506 in nonprofit funding for dermatology research in 2019 alone and US $9.3 billion dollars of private equity investment in dermatology health care and research between 2011 and 2021 [10,11].

Conclusions

Given the wide variety of factors that must be considered in order to optimally allocate research funding, several guidelines may help ensure that funding is prioritized for research efforts that will guide clinical practice, improve patient outcomes, and positively impact public health. In addition to prioritizing high-burden diseases, prioritizing funding for translational research can help expedite the incorporation of knowledge gained from basic science research into clinical practice and patient care. Periodically evaluating the real-world impact of funded research using metrics including patient outcomes and cost-efficacy can also help ensure that funding is being distributed to research that is meaningfully impacting clinical practice. Increased funding for conditions that are impacting our patients will allow innovative solutions that improve patient quality of life. With these guidelines in mind, disease burden can easily be incorporated as one of the many important factors that should be used to inform research funding allocation, clinical practice guidelines, and health policy.

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Conflicts of Interest

RD is the Editor-in-Chief of *JMIR Dermatology* but was not involved in the selection of this manuscript for publication.

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Abbreviations

DALY: disability-adjusted life year
GBD: Global Burden of Disease
NIH: National Institutes of Health
YLD: year lived with disability

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Leveraging AI Large Language Models for Writing Clinical Trial Proposals in Dermatology: Instrument Validation Study

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Abstract

Background: Large language models (LLMs) are becoming increasingly popular in clinical trial design but have been underused in research proposal development.

Objective: This study compared the performance of commonly used open access LLMs versus human proposal composition and review.

Methods: A total of 10 LLMs were prompted to write a research proposal. Six physicians and each of the LLMs assessed 11 blinded proposals for capabilities and limitations in accuracy and comprehensiveness.

Results: ChatGPT-o1 and Llama 3.1 were rated the most and least accurate, respectively, by human scorers. LLM scorers rated ChatGPT-o1 and DeepSeek R1 as the most accurate. ChatGPT-o1 and Llama 3.1 were rated as the most and least comprehensive, respectively, by human and LLM scorers. LLMs performed poorly on scoring proposals and, on average, rated proposals 1.9 points higher than humans for both accuracy and comprehensiveness.

Conclusions: Paid versions of ChatGPT remain the highest-quality and most versatile option of the available LLMs. These tools cannot replace expert input but serve as powerful assistants, streamlining the development process and enhancing productivity.

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KEYWORDS

artificial intelligence; AI; large language model; research proposal; clinical research; clinical trials; deep learning; machine learning; research design

Introduction

Advancements in artificial intelligence (AI) have led to the development of large language models (LLMs) using algorithms that learn from data and recognize patterns to make decisions based on all available data within a training set [1]. However, AI is limited by the data it is trained on and an inability to account for the nuanced contexts of individual research studies [2]. Researchers are increasingly using LLMs in clinical trial design to improve patient selection, cohort composition, and recruitment [3]. In contrast, the use of LLMs in research proposal development is largely unexplored, and thus, they are perhaps underused. This study aimed to address this gap by comparing the performance of LLMs versus the current gold standard of human proposal composition and review. Our goals were 3-fold: to rate LLMs in composing clinical trial proposals, assess LLMs in scoring clinical trial proposals, and evaluate the ease of using LLMs (including usability and efficiency).

Methods

Overview

Commonly used open access AI platforms (DeepSeek R1, ChatGPT-o3-mini [OpenAI], ChatGPT-o1 [OpenAI], ChatGPT-4o [OpenAI], Claude Sonnet [Anthropic], Claude Opus [Anthropic], OpenEvidence, Grok 2 [xAI], Gemini Advanced [Google], and Llama 3.1 [Meta AI]) were evaluated for use in research proposal drafting. We requested each of the models to do the following:

> *Write a research proposal for a study looking at the use of narrowband-ultraviolet B phototherapy for psoriasis treatment for psoriasis patients of varying skin pigmentation with 3 aims: 1. To understand the factors that affect the response of NB-UVB in psoriasis patients of varying skin pigmentation. 2. Evaluate adverse effects of NB-UVB and their impact on psoriasis patients of varying skin pigmentation. 3. Compare the acute immunologic response to NB-UVB*

in psoriasis patients of varying skin pigmentation using bulk and single-cell RNA sequencing. Include the following sections: 1 page 'Specific Aims' with details on each of the 3 aims, 1/2 page background and significance of the topic, 1 page of 'preliminary data/studies' relevant to the study, 1 page 'experimental design' (include summary of study, inclusion and exclusion criteria, study visits and procedures with an associated table describing specifics of study visits), 1/2 page of 'statistical methods, power calculations and bioinformatic analyses' specific for each aim, 1/4 page of 'potential problems and alternative strategies.' Please have approximately 30 references from reputable sources. Make the proposal a total of 7 pages long in paragraph form, in formal scientific language and at a graduate level.

To assess the outputs, each of the 11 blinded proposals (n=10, 90.9% LLM generated and n=1, 9.1% human written) was systematically reviewed and scored by 6 independent physician evaluators, all with strong research backgrounds. Each evaluator used a standardized Likert scale ranging from 1 to 5 (1="strongly disagree"; 5="strongly agree") to rate each proposal for capabilities and limitations in the LLMs' accuracy and comprehensiveness (Table 1).

Table . Criteria for assessing the accuracy, usability, comprehensiveness, and efficiency of large language models (LLMs).

Domain	Assessment criteria	Scoring methodology
Accuracy	Raters systematically fact-checked all proposal content. Only proposals with fully correct and verified factual information (including cited data, statistics, and conclusions) were rated highly. All references were checked for verifiability, relevance, and reputable source quality.	Rated independently by each evaluator on a Likert scale from 1 to 5 (1="strongly disagree: not accurate"; 5="strongly agree: fully accurate"). Scores were aggregated by calculating the mean of all raters' scores for each proposal.
Comprehensiveness	Assessed by evaluating inclusion and completeness of required proposal sections: specific aims, background and significance, preliminary data and studies, experimental design with inclusion and exclusion criteria and study visits and procedures, statistical methods, power calculations and bioinformatic analyses, and potential problems and alternative strategies. Proposals were further checked to meet format requirements: approximately 7 pages in length and 30 reputable references.	Rated independently on a Likert scale from 1 to 5. The mean score was calculated for all evaluators per proposal.
Usability	Assessed qualitatively based on researchers' (MH and DC) experience using each LLM. Criteria included intuitiveness of the interface, clarity of documentation, and ease of generating proposals without technical guidance.	Rated by 2 nontechnical investigators on a Likert scale from 1 to 5; scores were descriptively summarized.
Efficiency	The time from user input to final output was measured in minutes. Minimal delays and rapid response were rated favorably.	The time (minutes and seconds) for the LLM to complete the query was recorded.

For each domain assessed by human reviewers, individual scores were first tabulated. Scores from the 6 evaluators for each proposal were then aggregated by calculating the mean domain score, yielding an overall mean score per domain for each proposal. These aggregated scores provided a quantitative measure of each proposal's performance relative to evaluator consensus. No additional weighting was applied; each evaluator's score carried equal weight in the final aggregation.

In addition to scientific content review, LLM usability and efficiency, including description of pros and cons, were evaluated by 2 investigators. These qualitative evaluations were collected separately and did not contribute to the aggregated proposal scores.

Ethical Considerations

The authors have adhered to local, national, regional, and international law and regulations regarding protection of personal information, privacy, and human rights. This study did not involve human participants, identifiable private information, or interactions requiring human subjects protections. Accordingly, formal human ethics review approval was not required, and informed consent was not necessary. All data used in this study were deidentified prior to analysis to ensure participant confidentiality. No compensation was provided for participation in this study. These determinations are in accordance with University of Michigan policies and federal regulations (45 CFR 46) governing human research [4]. The research was conducted in compliance with the University of Michigan's guidelines on research ethics.

Results

LLMs Composing Proposals

The human-written proposal obtained a score of 5 for accuracy and comprehensiveness across all human scorers and remained the gold standard (Table 2). Human scorers rated ChatGPT-o1 as the most accurate and Llama 3.1 as the least accurate. When

assessed in scoring LLM-derived clinical trial proposals, LLM scorers rated ChatGPT-o1 and DeepSeek R1 as the most accurate (Multimedia Appendix 1). ChatGPT-o1 and Llama 3.1 were found to be the most and least comprehensive, respectively, by both human and LLM scorers.

Table . Full scores by evaluation criterion for each proposal and model.

Proposal and model	Accuracy (1-5), mean (SD)	Comprehensiveness (1-5), mean (SD)	Usability (1-5), mean (SD)	Efficiency
ChatGPT-4o	2.2 (1.2)	1.8 (1.4)	5.0 (0.0)	1 min, 37 s
Claude Opus	3.3 (1.4)	2.7 (0.6)	5.0 (0.0)	1 min, 30 s
ChatGPT-o1	3.5 (1.6)	4.3 (0.5)	3.5 (0.7)	1 min
ChatGPT-o3-mini	2.8 (1.7)	4.0 (0.6)	4.0 (0.0)	30 s
Claude Sonnet	2.0 (1.3)	1.8 (0.8)	4.0 (0.0)	28 s
DeepSeek R1	3.2 (1.5)	3.3 (1.4)	4.0 (0.0)	1 min, 23 s
OpenEvidence	2.3 (1.5)	1.3 (0.5)	3.5 (0.7)	45 s
Grok 2	3.2 (1.5)	3.0 (0.6)	4.0 (0.0)	1 min, 15 s
Gemini Advanced	2.5 (1.0)	1.5 (0.5)	4.5 (0.7)	37 s
Llama 3.1	1.7 (1.0)	1.5 (0.8)	4.5 (0.7)	20 s
Human proposal	5.0 (0.0)	5.0 (0.0)	N/A[a]	N/A (>10 working d)

[a]N/A: not applicable.

Mean and SD scores per criterion are reported for each proposal and model as assessed by 6 independent physician raters (except for usability, which was rated by 2 nontechnical investigators). Efficiency is reported as actual proposal generation time.

All raw scores are available in Multimedia Appendix 1.

LLMs Scoring Proposals

Overall, LLMs performed poorly on scoring proposals and, on average, rated proposals 1.9 points higher than humans for both accuracy (range 1.3-2.8) and comprehensiveness (range 0.7-3). The Claude Sonnet proposal showed the largest discrepancy between human and LLM scoring, with an average difference of 2.8 (SD 3.4) points for accuracy and 3 (SD 4.2) points for comprehensiveness. Interestingly, the ChatGPT-o1 and DeepSeek proposals both received top scores of 5 for both accuracy and comprehensiveness from all LLMs versus human averages of 4.3 (SD 2.2) and 3.3 (SD 1.9), respectively. The absence of variance at the top of the range (and wide variance in the middle of the range) suggests that the discriminatory power of the LLMs plateaued at the top LLM quality.

Ease of Using LLMs

All open access LLMs were highly efficient and ran in a matter of seconds to minutes (minimum of 20 seconds for Llama 3.1 and maximum of 1 minute and 37 seconds for ChatGPT-4o). When assessed for ease of use, ChatGPT-4o and Claude Opus offered the most intuitive interfaces and were highly usable for researchers (DC and MH) without computer science backgrounds.

Discussion

Principal Findings

LLMs offer powerful tools to assist humans in clinical trial proposal creation. LLMs take only minutes to generate proposals, whereas prior investigations into time commitment for generation of proposals by humans have reported estimates of 116 principal investigator hours, 55 coinvestigator hours, and 38 working days [5,6]. Therefore, judicious use of LLMs in proposal development allows researchers to save significant time in organizing sections, formatting, and ensuring coherence.

To provide guidance for readers, we performed a direct comparison of the tested LLMs, highlighting meaningful differences in performance, usability, and application. Table 3 summarizes these findings, with clear delineation of unique strengths and limitations for each model.

Table . Pros and cons of open access large language models (LLMs).

LLM (AI platform)	Pros	Cons
Overall	• Generally reliable, very user-friendly, and highly comprehensive and efficient	• Occasional factual inaccuracies and hallucinations (eg, fabricated references) • Lack of access to the most recent studies due to their training data cutoffs[a]
ChatGPT	• Most advanced and versatile option of the available LLMs • GPT-4o is the lowest-latency[b] and cheapest model	• Offers more advanced, paid "reasoning" models (GPT-o1 and GPT-o3), but they are computationally expensive and slower
Claude	• Designed with emphasis on alignment with human values • Tends to be more cautious about controversial or sensitive topics	• Models less tailored to clinical contexts compared to ChatGPT
DeepSeek	• Fully open source, promoting transparency and community contributions • Does not have associated license fees	• Struggles with fine-tuning on dialogue • Large models (eg, DeepSeek-Coder-33B) require large amounts of GPU[c] memory
Gemini	• Gemini 1.5 Pro boasts the largest context window[d] as a part of Google's ecosystem • Gemini 1.5 Flash is one of the fastest models	• Struggles to produce quality responses without significant prompt engineering • Concerns about data privacy and use with integration into various Google services
Grok 2	• Integration into X's (formerly known as Twitter) ecosystem allows Grok to stay up-to-date with current events and trends • Offers conversational capabilities tailored for social interaction	• Remains suboptimal compared to Claude 3.5 or GPT-4o • As a result of being directly linked to X, a platform with frequent user-generated content, Grok struggles to moderate sensitive or controversial interactions
Llama 3.1	• Llama 3.2 is one of the fastest models (along with Gemini 1.5) • Optimized for efficiency with lower computational requirements compared to other models	• Technical expertise required for it to run properly • Less user-friendly for researchers without technical support
OpenEvidence	• Offers access to the most recently curated medical research • Most robust and relevant citations	• Weaker reasoning capabilities than those of leading frontier models

[a]LLM training data cutoffs: October 2023 for ChatGPT, April 2024 for Claude Sonnet and July 2024 for Claude Haiku, December 2023 for Llama 3.1, May 2024 for Gemini, and unknown for OpenEvidence and Grok.

[b]Time to first token of tokens received, in seconds, after the application programming interface request is sent.

[c]GPU: graphics processing unit.

[d]Maximum number of combined input and output tokens.

ChatGPT-o1 and ChatGPT-o3-mini demonstrated the highest overall accuracy and comprehensiveness, delivering well-structured proposals with robust citations and high scientific rigor. Llama 3.1 and Gemini Advanced were notably efficient, reliably delivering full proposals with rapid turnaround times, but occasionally produced less nuanced sections in preliminary data or limited discussion. Regarding ease of use, ChatGPT-4o and Claude Opus feature intuitive interfaces and require minimal learning curves, making them ideal for researchers new to AI-powered tools. In contrast, Llama 3.1 and OpenEvidence ranked the lowest in usability as their technical requirements and specialized interfaces can be challenging for new users.

All open access LLMs can aid in initial outlining and creation of research proposals. They can assist in initial brainstorming of a clear researchable question and generating hypotheses based on existing literature. LLMs are useful in literature review and can summarize existing studies related to the proposal topic and identify gaps in current knowledge. Furthermore, all open access LLMs can propose data collection methods, define eligibility criteria based on study objectives, recommend appropriate statistical tests based on study design, and help draft proposal sections. They also allow for iterative refinements, enabling tailored outputs to meet specific requirements or needs. While human verification is always required, LLMs can greatly improve time spent on initial proposal drafting and aid in

mundane tasks associated with proposal writing, including proofreading and revisions, writing administrative sections, and optimizing citations.

Limitations to Consider

All LLMs operate similarly to traditional autocomplete and work by using available contextual clues and a statistical model to predict the most likely next "token" or word. Due to the training data cutoffs of AI models, researchers must manually incorporate the latest literature findings. AI researchers are working on incorporating more access to real-time data, for example, generative pretrained transformer actions [6], but these solutions come with their own trade-offs. Another limitation is that users must verify citations as the model may "hallucinate" or fabricate realistic-sounding but false information. Finally, although AI models such as DALL-E (or others) can create images, they are less effective at producing accurate, clinical-grade figures.

Additionally, current LLMs were largely unable to score proposals and should not replace human review for quality control. The high scores from the LLM raters indicate that the LLMs were unable to detect entire missed protocol sections. Other than Gemini Advanced (who self-scored its written proposal with 3 for accuracy and comprehensiveness), Claude Sonnet, and Llama 3.1, all the LLMs self-scored their own proposals with 5 for both accuracy and comprehensiveness, suggesting overlapping "blind spots" in LLM proposal generation and evaluation.

One limitation of this study is that the order in which the proposals were sent for respondents to review was not randomized. Additionally, the "gold standard" (human proposal) was last, and question order likely played a role, with kinder grading of the LLM-derived proposals before reviewing the human-written proposal. Had the human proposal been first, this would have highlighted missing components of LLM-derived proposals and likely led to harsher human grading of the latter.

Another important limitation is the rapid and frequent versioning of LLM platforms, which poses challenges for scientific reproducibility. As models are updated, their performance and outputs can meaningfully change over time, making it difficult to reproduce results or maintain consistency in studies that rely on AI-generated content. Researchers should document model versions and use dates to mitigate this issue and ensure transparency.

Conclusions

The future of AI in clinical research is expected to be transformative and far-reaching. As AI algorithms continue to evolve, they are likely to become more accurate, comprehensive, efficient, and interpretable, enabling researchers to leverage AI-driven insights for personalized medicine, disease prevention, and improved patient outcomes. In the coming years, AI is anticipated to play a crucial role in optimizing clinical trial design and accelerating drug discovery [7]. The integration of AI with other emerging technologies, such as blockchain and the Internet of Medical Things, could further revolutionize clinical research by improving data security, privacy, and real-time patient monitoring [8]. As these advancements continue to unfold, AI has the potential to democratize access to novel therapies, reduce health care costs, and, ultimately, usher in an era of precision medicine [9].

LLMs offer a transformative approach to drafting research proposals [10]. Paid versions of ChatGPT (ChatGPT-o3-mini and ChatGPT-o1) currently remain the highest-quality (as determined by the Artificial Analysis Quality Index) and most versatile option of the available LLMs, balancing usability, speed, accuracy, and customization [11]. While these tools cannot entirely replace expert input, they serve as powerful assistants, streamlining the development process and enhancing productivity. For optimal results, researchers should combine AI-generated content with their expertise, ensuring precision and adherence to the latest research standards.

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Data Availability

The data used in this study can be made available upon request to the corresponding author.

Authors' Contributions

Study conception and design were completed by MH and TT. Material preparation and data collection were performed by MH, DC, KY, TD, JSD, AY, JC, AB, and MN. Data analysis was performed by MH. The first draft of the manuscript was written by MH and DC, and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

Conflicts of Interest

None declared.

Multimedia Appendix 1
Human and large language model (LLM) scoring of LLM performance on accuracy and comprehensiveness.
[DOCX File, 21 KB - derma_v9i1e76674_app1.docx]

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Abbreviations

AI: artificial intelligence
LLM: large language model

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The Role of TikTok in Education on Hidradenitis Suppurativa in Skin of Color: Cross-Sectional Analysis

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Abstract

Abstract: This study analyzed 50 TikTok videos returned by a search for "hidradenitis suppurativa in Black skin," revealing that nearly half were patient-created, few had physician involvement (n=10, 20% dermatologists; n=7, 14% plastic surgeons), and few had commission-based (n=7, 14%) or sponsored content (n=2, 4%); they were predominantly patient testimonials on various treatments, highlighting the need for greater physician engagement to address patient needs, hidradenitis suppurativa product safety, and efficacy.

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KEYWORDS

TikTok; skin of color; hidradenitis suppurativa; patient education; social media

Introduction

TikTok has become a prominent platform and search engine for dermatologic information [1]. A majority of videos on the top 20 most commonly diagnosed skin conditions were created by patients [2]. This study aimed to evaluate the primary sources of education on hidradenitis suppurativa (HS) in Black skin on TikTok.

HS is a chronic inflammatory condition marked by sinus tracts, nodules, and abscesses in intertriginous areas [3]. It often affects African American women and is frequently misdiagnosed, leading to delayed identification, accelerated progression, and treatment challenges [4]. Black patients experience a 1.5-year longer diagnostic delay than White patients, and after diagnosis, they typically wait 5 years to see a dermatologist compared to 3 years for White patients [5]. Early intervention is critical to prevent advanced-stage manifestations, which are often refractory to standard therapeutic approaches [6].

A study on dermatologist visibility on TikTok found that most dermatologic education videos are made by individuals without formal medical training [7]. While these platforms allow patients to connect and share experiences with skin conditions, the risk of spreading misinformation is significant, potentially worsening disease severity and reducing treatment effectiveness. This study aimed to describe who produces HS TikTok content featuring Black skin and to quantify the treatments, products, and themes presented.

Methods

TikTok was selected because users often turn to the platform as a general search tool, including for health topics related to HS [1]. The app was used to search for "hidradenitis suppurativa in black skin" in the search bar. A total of 50 videos were viewed one by one by a single reviewer to assess the creator's role, brands or products discussed, key themes, and whether the products were part of paid sponsorships or if the creator received commission from sales.

Ethical Considerations

All data were deidentified prior to analysis. User IDs, screenshots, images, and quoted content contained no personally identifiable information. Data were analyzed and reported in anonymized form only.

Results

Of the 50 analyzed videos, 24 (48%) were created by patients. Board-certified dermatologists produced 10 (20%) videos, while board-certified plastic surgeons produced 7 (14%) videos. One (2%) video was created by a nurse practitioner. Beauty service providers accounted for 2 (4%) videos. The "other" category, which included dietitians, social workers, product creators, and creators with unclear professional titles, accounted for 6 (12%) videos. Board certification status was verified using creator profile biographies and linked professional websites.

Seven videos featured products associated with sales commissions, and 2 videos involved paid sponsorships.

Treatment content represented the largest category, comprising 35 (70%) videos (Table 1). Fourteen (28%) of the 50 videos focused on explaining HS. Of these, 9 (18%) were created by health care professionals, 4 (12%) by patients, and 1 by a product creator. The remaining videos focused on living with HS and dietary approaches to symptom management.

Table . Video themes stratified by creator type across 50 analyzed videos.

	Video type, n				
Creator type	Education	Medical treatment	Over-the-counter treatment	Lifestyle	Mental health
Patient	4	4	14	4	3
Board-certified dermatologist	7	3	5	0	0
Board-certified plastic surgeon	1	2	3	0	0
Nurse practitioner	1	0	0	0	0
Beauty service provider	0	1	1	0	0
Other	1	0	3	0	0

Products appeared across multiple categories, including face masks and exfoliants, body scrubs and cleansers, acne treatments, topical oils, salves, body butters, creams, antiseptics, spot treatments, systemic medications, and hair or scalp care, as shown in Table 2. PanOxyl and Hibiclens washes were the most frequently recommended products, appearing in 5 (10%) and 6 (12%) videos, respectively. Magic Healer body butter was mentioned in 4 (8%) videos, and Humira was mentioned in 3 (6%) videos. CeraVe acne foaming cream cleanser, a turmeric kojic acid soap, and Tend Skin Solution were all separately mentioned in 2 (4%) videos. All other products were mentioned in one video each.

Table . Categories of products mentioned across 50 analyzed hidradenitis suppurativa–related videos.

Category	Products
Face masks and exfoliants	Skinfix Glycolic Renewing Mask, Cocokind Turmeric Mask
Body scrubs and cleansers	Skinfix body scrub, Olay body wash, Naturium Vitamin C body wash, lemon turmeric and kojic acid soap, Dr. Bronner's Soap, turmeric kojic acid soap, Dial bar soap
Acne cleansers and treatments	PanOxyl, PanOxyl acne foaming wash, Inkey List 5 % Benzoyl Peroxide Cleanser, CeraVe acne foaming cream cleanser, Zapzyt, Tend Skin Solution
Topical oils and salves	Relief Natural Company, GuruNanda Tea Tree, Zunda Turmeric, black seed oil, vitamin E, clove water, Magic Healer body butter, Palmer's Body Oil
Body butters, creams, and moisturizers	HS Body Butter, Fenty Skin Cream, Healing Ocean Cream
Antiseptics and antimicrobials	Hibiclens, Magic Healer Product
Specialty treatments and patches	Mighty Patch
Medications	Humira
Hair and scalp care	Head & Shoulders

Discussion

Patients produced the majority of lifestyle-based and experiential content, while physicians concentrated on treatment education and procedural intervention. Commercial messaging remained isolated to product owners and patient testimonials, with minimal clinical creator involvement. This distribution highlights a content gap between medically accurate education and the lived experience narrative dominating public HS discourse on TikTok. Research shows that only about 20% of skin of color videos are created by board-certified dermatologists [8]. These findings highlight an opportunity for dermatologists on TikTok to engage with patients and address the safety and efficacy of these products. Dermatologists, who already have a strong social media presence, can foster patient trust by encouraging open discussions about non–medical-grade treatments. By acknowledging the value of herbal and alternative remedies that patients find helpful, they can assess their safety and efficacy while supporting their continued use when appropriate. Meanwhile, they can provide evidence-based guidance to minimize the risks of harmful or ineffective treatments.

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Conflicts of Interest

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Abbreviations

HS: hidradenitis suppurativa

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Navigating the Intersection of Radiofrequency Microneedling and Surgical Facelifts: Scoping Review

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Abstract

Background: Optimal management of facial skin laxity requires a nuanced approach by health care providers working in aesthetics. Radiofrequency microneedling (RFMN) devices have emerged as a popular noninvasive treatment for facial rejuvenation and improving skin laxity. While RFMN has demonstrated efficacy in enhancing skin tightening and complementing aesthetic procedures, its long-term impact on subsequent surgical facelifts remains uncertain.

Objective: The objective of this scoping review is to explore the interplay between RFMN and surgical facelift outcomes, with a focus on potential complications such as excessive skin tightening, dermal scarring, and altered tissue planes that may pose surgical challenges.

Methods: A search using PubMed and Google Scholar was conducted, and articles were selected from peer-reviewed journals based on specific inclusion and exclusion criteria. Only articles available in English were selected. In total, 21 articles were included in this scoping review.

Results: Papers included in this review discussed the mechanisms of action involved with RFMN, RFMN-related tissue changes, and how these changes could impact future facelift procedures. Most of the papers found that RFMN may drastically alter multiple tissue planes involved in facelift procedures due to collagen deposition through multiple tissue layers and increased tissue fibrosis. Patient factors influencing the effectiveness of RFMN and its role in facial rejuvenation were also examined, emphasizing the importance of navigating patient-specific demographics as a future consideration when creating an individualized treatment plan for each patient.

Conclusions: Patients should be informed that RFMN may lead to dermal fibrosis, tissue adhesions, and altered superficial musculoaponeurotic system composition, which could interfere with future facelift procedures and the patient's desired treatment goals. This emphasizes the importance of detailed discussion between the patient and health care provider to improve pretreatment consultation, increase patient education, and set realistic expectations. Further research is needed to determine optimal timing and treatment strategies for patients considering both RFMN and surgical facelifts to achieve the best aesthetic outcomes.

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KEYWORDS

radiofrequency; microneedling; facial; laxity; facelift

Introduction

Radiofrequency (RFMN) microneedling is a minimally invasive procedure that combines mechanical injury and thermal stimulation via tiny microneedles with radiofrequency (RF) energy to induce collagen remodeling [1]. The microneedling component creates controlled microtraumas, triggering a postinflammatory cascade that promotes neocollagenesis, elastin production, and angiogenesis. RF energy delivered through the microneedles then generates thermal coagulation within the dermis and hypodermis to induce collagen denaturation and subsequent contraction of tissue for skin tightening benefits [2]. This fractional approach allows for targeted treatment while preserving surrounding tissue, reducing recovery time [3]. Compared to traditional microneedling, evidence suggests that RFMN brings about greater improvements in aged skin, likely by eliminating senescent fibroblasts and increasing the number of nonsenescent fibroblasts [4].

A systematic review done in 2021 by Tan et al [5] analyzed 42 studies evaluating RFMN use across various conditions, with the largest evidence base for skin rejuvenation, followed by acne scars, acne vulgaris, striae, and axillary hyperhidrosis. A smaller number of studies were available supporting RFMN use for melasma, rosacea, cellulite, and androgenetic alopecia.

Based on the large and growing body of evidence for skin rejuvenation, RFMN devices have gained immense popularity for addressing skin laxity in patients seeking noninvasive alternatives to surgical facelifts. These devices offer treatment options for individuals outside the average age range for a facelift, those who have previously undergone a facelift, or patients desiring minimally invasive interventions [5]. Advances in RFMN technology, such as interchangeable tips with various microneedle pin configurations and dual treatment modes, allow for targeted treatments in delicate anatomical areas like the periorbital region [5]. While these technological refinements enhance customization, the process may impact deeper dermal structures critical to surgical outcomes, setting the stage for potential interference with future facelift procedures.

Long-term effects of RFMN before surgical facelifts remain unclear, raising concerns about potential complications. RFMN treatment prior to an elective facelift may have the potential to interfere with optimal facelift results due to excessive skin tightening, scarring, and damage to the dermis. This emphasizes the importance of pretreatment discussion about expectations and the adverse effects of RFMN if it is being used with a patient who is considering a facelift in the future. Given the interplay between RFMN and surgical facelifts, what are the long-term implications of RFMN for patients who may eventually pursue surgical facelift procedures? Could the very technology we're using to delay surgery unintentionally complicate it later? This scoping review explores the anatomical and clinical intersections between RFMN and surgical facelifts for patients realistically considering either a facelift or RFMN. It draws on current literature, evolving device technology, and real-world considerations to guide thoughtful treatment planning for optimal patient outcomes.

Methods

Searches done on PubMed and Google Scholar using the terms "skin laxity and radiofrequency microneedling," "skin laxity and microneedling," "skin laxity and facelift," "facelift and radiofrequency microneedling," and "facelift and microneedling" were conducted on January 4, 2024, and again on June 20, 2025, to account for any newly published or updated literature since the original search. The second search did not yield any new articles. Articles from peer-reviewed journals were included if they provided information on the mechanism of action of RFMN, described the techniques involved when performing a facelift procedure, or examined the effects of RFMN and/or facelift procedures on the skin. Only articles available in English were selected, and articles were excluded if they provided information on the use of RFMN on parts of the body other than the face and neck, or if they described RFMN treatment or surgical intervention unrelated to improving facial skin laxity. A summary of the inclusion and exclusion criteria are highlighted in Textbox 1. The review was conducted based on the 2005 methodology of Arksey and O'Malley [6]. The Preferred Reporting Items for Systematic Reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR) reporting guidelines were followed, and the completed PRISMA-ScR checklist for this review can be found as Checklist 1.

Textbox 1. Inclusion and exclusion criteria.

Inclusion criteria

- From peer-reviewed journals
- Content of article: mechanism of action of radiofrequency microneedling (RFMN); facelift procedures; effects of RFMN and/or facelift procedures on the skin
- Available in English

Exclusion criteria

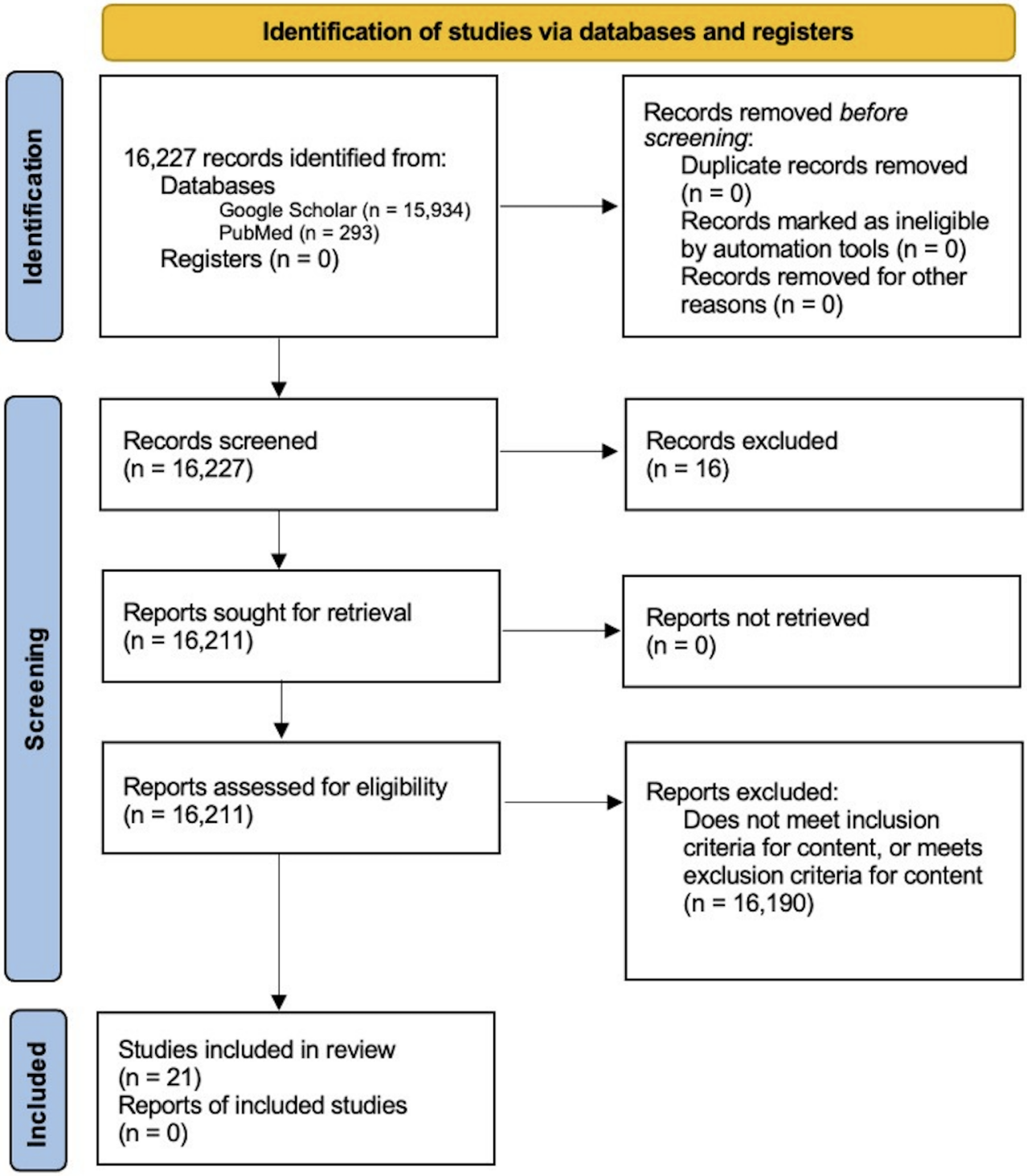
- Content of article: RFMN being used on parts of the body other than the face and neck; RFMN treatment or surgical intervention unrelated to improving facial skin laxity
- Not available in English or an English translation

Results

Article Selection

From the initial search using the selected search terms, 15,934 and 293 articles were respectively identified from Google Scholar and PubMed, for a total of 16,277 articles (Figure 1). Out of the 16,277 articles screened, 16 PubMed articles were excluded because they were not available in English. Google Scholar does not have a language screening filter, so all 15,934 articles from the initial search were still considered. After all authors screened the remaining articles for content based on the inclusion and exclusion criteria, 21 articles in total were selected for this review. A PRISMA diagram of the article selection is available below in Figure 1.

Figure 1. Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) diagram of article selection.



Summary of Included Articles

After article screening was completed and the 21 articles were selected, 12 articles were identified as original research, 5 as narrative literature reviews, 2 as systematic reviews, and 1 as an educational reference article. One article, by Arksey and O'Malley [6], was used as a framework to guide writing of this review, and did not necessarily fit the inclusion and exclusion criteria for articles specifically related to the topic of this scoping review. Table 1 displays a summary of the articles mentioned, as well as their article types and study designs.

Table . Summary of included articles.

Authors (year)	Journal	Article type	Study design
Devgan et al (2019) [1]	*Otolaryngology Clinics of North America*	Literature review	Narrative review
Spataro et al (2022) [2]	*Facial Plastic Surgery Clinics of North America*	Literature review	Narrative review
Hendricks and Farhang (2022) [3]	*Journal of Cosmetic Dermatology*	Literature review	Narrative review
Hwang et al (2025) [4]	*Scientific Reports*	Original research	Split-face comparative clinical trial
Tan et al (2021) [5]	*Dermatologic Surgery*	Literature review	Narrative review
Arksey and O'Malley (2005) [6]	*International Journal of Social Research Methodology*	Original research	Not applicable
Dayan et al (2020) [7]	*Plastic and Reconstructive Surgery—Global Open*	Original research	Prospective case series (single-arm clinical study)
Arnaoutakis et al (2022) [8]	*Facial Plastic Surgery & Aesthetic Medicine*	Literature review	Narrative review
Ramaut et al (2018) [9]	*Journal of Plastic, Reconstructive & Aesthetic Surgery*	Systematic review	Systematic review
Huang et al (2014) [10]	*Biochemistry*	Basic science research	In vitro experimental study
Nguyen et al (2025) [11]	*Lasers in Medical Science*	Original article	Clinical and histologic study (prospective cohort)
Xu et al (2025) [12]	*Lasers in Surgery and Medicine*	Original research	Animal study (porcine model)
Zheng et al (2014) [13]	*Dermatologic Surgery*	Original research	Experimental histologic study
Wang et al (2025) [14]	*Lasers in Medical Science*	Original research	Pilot clinical study
Wang et al (2024) [15]	*Lasers in Surgery and Medicine*	Original research	Animal study (porcine model)
Cho et al (2024) [16]	*Skin Research & Technology*	Original research	Animal study (minipig model)
Hohman et al (2023) [17]	*StatPearls*	Reference article	Narrative review (educational)
Ghassemi et al (2003) [18]	*Aesthetic Plastic Surgery*	Original research	Anatomical cadaveric study
Demesh et al (2021) [19]	*Journal of Cosmetic Dermatology*	Original research	Clinical case series
Seo et al (2012) [20]	*Lasers in Surgery and Medicine*	Original research	Clinical and histologic study (prospective cohort)
Austin et al (2022) [21]	*Lasers in Surgery and Medicine*	Systematic review	Systematic review

RFMN-Related Tissue Changes

While RFMN effectively improves skin laxity and wrinkle reduction, its impact on future facelift procedures remains uncertain. An article published in 2022 found that a single session of noninvasive fractional bipolar RFMN achieved approximately 37% of the skin laxity improvement seen with a surgical facelift, suggesting multiple treatments may be required for significant results [8]. However, a 2018 systematic review from the *Journal of Plastic, Reconstructive & Aesthetic Surgery* states that repeated sessions risked dermal fibrosis, particularly in the papillary dermis, potentially complicating future surgical interventions [9].

As RFMN devices introduce repeated and organized microtraumas into the skin, the depth of penetration directly impacts targeted tissue layers. Microneedling from such devices introduces a targeted mechanism of repair that excludes highly inflammatory cellular cascades, such as transforming growth factor β-1 (TGF-β1) and transforming growth factor β-2 (TGF-β2), and instead is driven through a less-inflammatory cascade via transforming growth factor β-3 (TGF-β3), a protein known to lead to fibroblast migration and collagen matrix remodeling [10]. Platelet-derived growth factor (PDGF), fibroblast growth factor (FGF), and epidermal growth factor (EGF) are all released locally in response to the microtrauma, allowing natural skin tightening via angiogenesis and collagen deposition [2]. Repeated treatments thus increase collagen deposition, which increases the risk for the development of dermal fibrosis.

A better understanding of the timeline of collagenesis following RFMN is critical when considering the interplay with surgical facelifts. Acute inflammation and early collagen deposition dominate the first week after treatment, followed by organized collagen remodeling and maturation over the ensuing 1 to 3 months [2,10]. Persistent changes in dermal structure, including fibrosis or altered tensile strength, may interfere with surgical flap elevation, tissue pliability, and healing after a facelift.

RFMN energy settings can be optimized to balance skin tightening with control of fibrosis by titrating energy per needle,

pulse duration, and depth to achieve sufficient dermal coagulation for neocollagenesis and elastogenesis while avoiding excessive thermal injury that may promote fibrotic remodeling. Data supports targeting moderate energy settings (eg, energy per needle 20 - 60 mJ, pulse durations 100-300 ms) and limiting the number of passes to induce controlled dermal coagulation, maximizing skin tightening while minimizing the risk of fibrosis [11,12]. Adjusting needle depth to target the reticular dermis and using insulated needles can further localize RFMN thermal effects, thus reducing epidermal damage and unwanted fibrosis [13,14]. Sequential or pulsed energy delivery, as well as energy feedback systems, can help regulate tissue response and prevent overtreatment [15,16].

Effects on Future Elective Facelift Procedures

Surgical facelift procedures rely on the manipulation of the superficial musculoaponeurotic system (SMAS), a fibrofatty connective tissue layer continuous with the superficial cervical fascia, connected to the platysma muscle inferiorly and the galea superiorly [17]. It plays an integral role in the anatomic relation of the superficial dermis to the underlying facial muscles. There are two distinct SMAS compositions given anatomic regions, and the abrupt junction of differing compositions resides at the nasolabial fold region, where medially, there are fewer fat lobules and a more direct connection of the SMAS to the superficial dermis as muscle fibers are seen to extend superficially into the dermis [17]. However, the other regions of the SMAS lateral to the nasolabial fold still carry the same properties of communication of facial muscle to skin by muscle tendon fibers connecting both regions via the SMAS [18]. Beneath this layer, the SMAS has a complex relation with deep ligaments and connections that limits the mobility of superficial structures. These connections are crucial to release to generate the most optimal movement for desired facelift outcomes [17].

Due to the sophisticated relationship of neighboring structures, RFMN, particularly at greater depths, may alter these structural relationships. Traditional surgical facelifts target a single plane of tissue in a primary horizontal plane [17]. On the contrary, RFMN targets a small treatment area in a vertical configuration through multiple planes of tissue, potentially leading to increased tissue adhesions, difficult surgical dissection, impaired flap mobility, and suboptimal facelift outcomes [10].

Although undergoing RFMN treatments prior to a facelift could potentially induce a level of fibrosis that may help delay the timeline when a patient would be a candidate for a facelift, evidence suggests RFMN may be more beneficial postoperatively. Following a facelift, RFMN could enhance skin tightening and improve aesthetic outcomes by stimulating additional collagen production either as an immediate adjunctive therapy or as a method to combat recurrent long-term skin laxity [19]. Careful planning is necessary to determine the appropriate time frame between treatments to avoid excessive fibrosis and impaired wound healing.

Patient Considerations for RFMN Procedures

When considering therapy using RFMN, specific patient populations should be considered when discussing treatment options, as certain age groups, as well as patients with jowl laxity, have been shown to experience better outcomes with facial surgery [19]. Taking into consideration that each treatment has varying mechanisms and different anatomical targets, a comparative study found that surgical facelifts improved skin laxity by 46% relative to baseline, whereas RFMN alone achieved only a 16% improvement [20]. These findings underscore the importance of setting realistic patient expectations regarding treatment efficacy. Additionally, patient age should be considered, as older individuals (≥55 years) experience more pronounced skin tightening with RFMN compared to younger patients [2]. Younger patients typically have a higher collagen content in their skin compared to older patients, who undergo collagen loss due to age; thus, the relative resulting decrease in skin laxity is much more noticeable in older patients versus younger patients. This knowledge prompts early discussion of RFMN treatment to address its potential effectiveness or lack thereof, especially at a younger age.

In addition to considering a patient's age, premature neck and jowl laxity are common concerns among patients seeking skin-tightening treatments. However, RFMN does not effectively target subplatysmal fat, necessitating careful patient selection—individuals with significant subplatysmal fat may achieve superior results with surgical interventions such as liposuction [19]. For patients with pronounced skin laxity, RFMN alone may be insufficient and could exacerbate sagging if incidental heat-induced fat loss occurs without concurrent skin excision [19]. Other complications of RFMN reported include hyper- or hypopigmentation of treated skin, thermal burns, blistering, and scarring; these can often be mitigated with proper technique and equipment settings [8].

Discussion

Main Findings

The nuances of RFMN in facial rejuvenation necessitate a deeper understanding of its implications for future surgical facelifts. This calls for detailed discussion between the patient and health care provider to improve pretreatment consultation, patient education, and results. Patients should be informed that RFMN may lead to dermal fibrosis, tissue adhesions, subcutaneous adipose denaturation, and altered SMAS composition, which could complicate facelift procedures and their desired outcomes. Additionally, providers should address the limitations of RF to effectively target jowl laxity and set realistic expectations regarding RF results in patients younger than 55 years. Understanding these points would allow for individualized treatment planning, ensuring patients receive the most appropriate interventions based on their anatomical considerations and aesthetic goals. Furthermore, current evidence suggests RFMN may be better positioned as a postoperative adjunct rather than a presurgical intervention, especially in patients known to be surgical candidates in the future.

It is also important to note that RFMN has primarily been used for skin rejuvenation, mild laxity, and conditions such as acne scars, rather than as a substitute for surgical facelift procedures [5]. Additional systematic reviews and clinical trials, such as those by Austin et al [21] and Nguyen et al [11], further support

that early RFMN and radio frequency protocols are designed for modest rejuvenation, targeting mild-to-moderate laxity and stimulating collagen production. Among these studies, reported patient satisfaction was highest among those seeking subtle improvements rather than facelift-level results.

Limitations

This scoping review is limited by the minimal availability of long-term studies specifically examining the effects of RFMN on subsequent surgical facelift procedures. The available literature mainly consists of case reports, small-scale studies, and expert opinion, which restricts the generalizability of conclusions. In addition, the large amount of variation between RFMN device settings, treatment protocols, and patient demographics across studies further limits the ability to standardize findings or establish definitive treatment guidelines.

Conclusion

Cosmetic surgical providers trained in RFMN and/or facelift procedures should give careful consideration to this new technology when discussing different options for facial rejuvenation. Factors to weigh in these considerations should include, but are not limited to, age-related expectations, area of treatment, and the potential impact of subsequent facelifts. Rather than viewing RFMN and surgical facelifts as isolated interventions, providers should consider how early noninvasive treatments may influence future surgical options. This has important implications for clinical decision-making, patient education, and informed consent.

Ultimately, optimizing aesthetic outcomes will require a more integrated strategy that aligns patient goals with both immediate and long-term treatment trajectories. Future studies are needed to evaluate the cumulative impact of RFMN on facial anatomy and to guide safe, evidence-based treatment planning for patients considering both noninvasive and surgical facial rejuvenation options. Additional research should also focus on establishing guidelines for the optimal timing of RFMN relative to surgical facelifts and identifying strategies to minimize adverse effects of RFMN. As RFMN technology evolves, ongoing studies will be critical in refining its role in facial rejuvenation and improving patient outcomes.

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Conflicts of Interest

None declared.

Checklist 1
PRISMA-ScR checklist.
[DOCX File, 19 KB - derma_v9i1e78385_app1.docx]

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Abbreviations

EGF: epidermal growth factor
FGF: fibroblast growth factor
PDGF: platelet-derived growth factor
PRISMA-ScR: Preferred Reporting Items for Systematic Reviews and Meta-Analyses extension for Scoping Reviews
RF: radio frequency
RFMN: radio frequency microneedling
SMAS: superficial musculoaponeurotic system
TGF-β1: transforming growth factor β-1
TGF-β2: transforming growth factor β-2
TGF-β3: transforming growth factor β-3

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Patient Perceptions of Climate Change Impacts on Atopic Dermatitis: Cross-Sectional Survey Study

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Abstract

This cross-sectional survey study (63.5% response rate) characterized how patients with atopic dermatitis (AD) perceive and experience the effects of climate change on their AD. Most participants reported that environmental factors such as heat and air pollution worsened their AD and expressed a desire for climate-health education, yet few had discussed these concerns with their dermatologist. These findings reveal a gap in patient-centered dermatologic care and support the development of tools to integrate environmental health into atopic dermatitis management.

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KEYWORDS

atopic dermatitis; eczema; climate change dermatology; climate change; environmental health; climate health impacts; patient experience; survey study; health communication; patient education

Introduction

Climate change is recognized as the foremost global health threat of the 21st century [1]. Environmental shifts (rising temperatures, air pollution, and extreme weather) can impair the skin barrier, alter the microbiome, and induce inflammation, increasing the prevalence and severity of atopic dermatitis (AD) among other skin conditions [2,3]. Among dermatologists, 79.6% agree it affects their patients [4]. Yet, few routinely discuss this with patients, and limited research explores how patients perceive and experience these impacts. To address these gaps, this cross-sectional study surveyed patients with AD to assess how they perceive climate change's impact on their condition and whether these concerns are addressed in dermatologic care.

Methods

Survey Instrument Development

The survey was informed by climate-health literature, dermatologic environmental impacts, and health communication frameworks (eg, message framing, perceived susceptibility, and severity from the Health Belief Model) [5]. Five UCSF (University of California, San Francisco) dermatologists reviewed the instrument for clinical relevance and clarity. Ten adult AD patients piloted it, and feedback informed wording and usability.

Study Population & Recruitment

Eligible participants were English-speaking adults with AD seen at UCSF dermatology clinics between August 2023 and August 2024. A total of 2164 patients were identified by the electronic health record (EHR) query. To reduce selection bias, patients were contacted via EHR messaging or mailed letters to account for differences in digital health access; 326 patients expressed interest and became the study population. These patients were sent the study description and a secure Qualtrics link to the online survey.

Statistical Analysis

Descriptive statistics using Microsoft Excel were used to summarize participant demographics and survey responses. Frequencies were calculated for categorical variables. No inferential or hypothesis testing was conducted, as the study aimed to characterize trends and patient-reported experiences rather than test associations or determine causality.

Ethical Considerations

This study received exempt certification from the UCSF medical ethical review committee (IRB 21 - 33538). All participants provided consent to participate in the study, and their responses were deidentified.

Results

Of 326 individuals, 207 completed the survey (63.5% response rate). A majority of individuals (n=166/207, 80.2%, 95% CI

74.8% - 85.6%) reported that environmental-climate factors impact their AD, particularly extreme heat (n=157, 75.8%, 95% CI 70.0% - 81.7%) and poor air quality (n=81, 39.1%, 95% CI 32.5% - 45.8%). Commonly reported effects included increased medication use (n=168, 81.2%, 95% CI 75.8% - 86.5%), more symptomatic flares (n=167, 80.7%, 95% CI 75.3% - 86.1%), more skin affected (n=139, 67.1%; 95% CI 60.8% - 73.5%), and changes to daily behaviors (n=130, 62.8%; 95% CI 56.2% - 69.4%). Most participants (n=179, 86.5%; 95% CI 81.8% - 91.1%) expressed interest in understanding how environmental-climate factors affect their AD, yet only 76 participants (36.7%; 95% CI 30.1% - 43.3%) said their dermatologist addressed these concerns. The most valued strategies for addressing climate-health impacts included more information (n=164, 79.2%; 95% CI 73.7% - 84.8%), dedicated time during visits to plan for exposures (n=105, 50.7%; 95% CI 43.9% - 57.5%), and more in-person visits (n=101, 48.8%; 95% CI 42.0% - 55.6%). Table 1 shows participant characteristics, and Table 2 shows survey response data.

Table . Participant demographics and background information.

Demographics	Participants (N=207)
Age in years (mean, SD)	46.4 (18.6)
Sex, n (%)	
Male	75 (36.2)
Female	129 (62.3)
Nonbinary	3 (1.4)
Race/Ethnicity, n (%)	
American Indian or Alaskan Native	2 (1.0)
Asian or Asian American	82 (39.6)
Black or African American	12 (5.8)
Hispanic or Latino	12 (5.8)
Native Hawaiian or Pacific Islander	1 (0.5)
White	107 (51.7)
Other	5 (2.4)
Years living with atopic dermatitis (mean, SD)	21.6 (18.3)
Treatments used for atopic dermatitis, n (%)	
Topical steroid	193 (93.7)
Topical medication other than a steroid	145 (70.4)
Topical over the counter product (does not require a prescription)	139 (67.4)
Pill medication (eg, methotrexate, cellcept, tofacitinib, upadacitinib)	47 (22.8)
Injection medication (eg, dupilumab, tralokinumab)	94 (45.6)
Phototherapy	41 (19.9)

Table . Responses to survey questions using the 5-point Likert scale, where 1 indicates "Strongly disagree," 2 "Somewhat disagree," 3 "Neutral," 4 "Somewhat agree," and 5 "Strongly agree." A reported mean greater than 3 indicates agreement and less than 3 indicates disagreement.

Statement, agreement ranked using the 5-point Likert scale	Score, mean (SD)
Climate and environmental factors have impacted your experience with eczema	4.2 (1.0)
The following factor has impacted your experience with eczema:	
Extreme Heat	4.2 (1.1)
Wildfires	3.3 (1.1)
Poor Air Quality	3.4 (1.1)
Drought	3.2 (1.1)
Extreme Rainfall	3.0 (1.3)
Sea Level Rise	2.4 (1.0)
Flooding	2.6 (1.1)
Climate and environmental factors' impact on your eczema include:	
More symptomatic with exacerbations or flares	4.2 (1.0)
More skin affected	3.9 (1.2)
Need for extra appointments with healthcare team	3.1 (1.2)
Sending additional messages to dermatologist or calling their office	3.0 (1.2)
Using medication more often	4.1 (1.0)
Change to your medication	3.2 (1.3)
Change to lifestyle or daily behaviors	3.8 (1.1)
You want to know how the climate and environment impact your eczema	4.2 (1.0)
Your dermatologist has talked about how the climate and environment affect your eczema	2.9 (1.3)
This strategy would be helpful in managing changes to your eczema from the climate and environment:	
More visits in person	3.4 (1.1)
More telehealth visits	3.2 (1.1)
Time during visits to make plans for climate or environmental problems	3.5 (1.1)
More information on the topic	4.1 (0.9)
Support groups	2.9 (1.1)

Discussion

Principal Findings

While this study does not evaluate clinical causality, it provides novel insight into how patients perceive and experience the effects of environmental-climate factors on their AD. Most participants perceived climate-related changes in their AD and desired clinical guidance, yet few reported receiving it. These findings suggest that dermatologists should initiate brief conversations about common triggers, particularly heat and air pollution, and provide anticipatory guidance and resources. This insight underscores previously reported low self-efficacy among dermatologists in discussing climate change with patients [4]. Understanding these patient insights is vital to providing patient-centered care and forming effective partnerships with patients about their skin health. These efforts align with the American Academy of Dermatology's commitment to "educate our patients about the effects of climate change on the health of their skin." [6]

Limitations and Future Direction

Limitations include a single-center design limiting generalizability, reliance on self-reported data with potential recall bias, and possible self-selection bias, as patients more affected by climate change may have been more likely to participate. Future research should validate these findings in broader populations, explore climate-health experiences in other skin conditions, and develop educational and clinical strategies to help navigate these climate-health conversations with patients. Even in short visits, dermatologists can explore patient experiences with climate change using supportive prompts (eg, "Would it be helpful to discuss how environmental factors might relate to your flares?") to validate patient concerns and provide opportunities for personalized climate-health conversations to be continued in subsequent visits.

Conclusions

This study highlights a disconnect between how patients with AD experience climate-related triggers and how often these

concerns are addressed in clinical care. Findings underscore the need for tools and strategies to support climate-health conversations in dermatology. Integrating environmental health into AD management can enhance patient-centered care, improve outcomes, and reinforce dermatology's role at the intersection of clinical care, public health, and patient advocacy.

Data Availability

The datasets generated or analyzed during this study are available from the corresponding author on reasonable request.

Conflicts of Interest

None declared.

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Abbreviations

AD: atopic dermatitis
EHR: electronic health record
UCSF: University of California, San Francisco

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Differences in Electronic Consultation Conversion Rates Between Advanced Practice Providers and Board-Certified Dermatologists

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Abstract

In this analysis of dermatology e-consults at a large academic health system, advanced practice providers had nearly threefold higher conversion rates to in-person visits compared to board-certified dermatologists, with potential implications for access and resource utilization.

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KEYWORDS

e-consult; telehealth; dermatology; advanced practice provider; teledermatology

Introduction

Electronic consultations (e-consults) have become an increasingly valuable tool in improving access to specialty care, reducing unnecessary in-person referrals, and supporting timely management of patients by primary care providers [1,2]. By allowing clinicians to consult with specialists asynchronously through the electronic health record, e-consults can help streamline workflows, decrease wait times, and conserve specialist resources [2,3]. Dermatology services receive a high number of e-consult requests, likely due to the visual diagnostic nature of the specialty [3,4]. As the use of e-consults expands across health care systems, understanding how different provider types use this tool, particularly in high-demand specialties such as dermatology, is critical to optimizing efficiency and effectiveness. Furthermore, identifying whether variations in conversion patterns reflect provider-level practice differences or system-level routing processes is essential for ensuring that e-consults function as intended.

Methods

We conducted a retrospective analysis to evaluate whether e-consult conversion rates differed by provider type, specifically comparing advanced practice providers (APPs), including nurse practitioners and physician assistants, to board-certified dermatologists. e-consult data specific to dermatology were extracted from the University of Colorado Hospital electronic health record system for the period of January 2020 to April 2025. An e-consult was considered “converted” if it resulted in a subsequent in-person specialist visit or full referral, rather than being resolved entirely through asynchronous communication.

In this system, e-consults are routed to APPs versus dermatologists primarily based on provider availability rather than consult content or patient acuity. As a result, patients evaluated by APPs and physicians likely represent comparable clinical populations, reducing the likelihood that differences in conversion rates were driven by systematic triage of more complex cases to one provider group.

Results

A total of 2572 dermatology e-consults were submitted during the study period. Of these, 1205 were addressed by APPs, with 321 (26.6%) resulting in conversion to an in-person visit (Table 1). In contrast, only 125 of the 1367 e-consults addressed by physicians (9.1%) were converted (Table 2). e-consults managed by APPs were nearly three times more likely to lead to an in-person referral compared to those managed by physicians.

Table . Total number and percentage of e-consults converted from advanced practice professionals.

e-consult converted	N (%)
No	884 (73.4)
Yes	321 (26.6)
Total	1205 (100.0)

Table . Total number and percentage of e-consults converted from dermatologists.

e-consult converted	N (%)
No	1242 (90.9)
Yes	125 (9.1)
Total	1367 (100.0)

Discussion

This analysis reveals a notable difference in e-consult conversion rates between APPs and physicians. This disparity suggests potential differences in how each provider group approaches triage and decision-making in specialty care. If APP-handled e-consults were converted at the same rate as physician-handled e-consults, over 200 additional dermatology clinic appointments during the study period may have been available for patients with higher-acuity needs. Despite this variation in appointment conversion, it is important to note that the majority of e-consults from both groups were resolved without the need for in-person follow-up. This reinforces the broader value of e-consults in improving efficiency and reducing unnecessary specialist visits and aligns with current literature [2,3].

The higher conversion rate observed among APPs may reflect a range of underlying factors. One possibility is that APPs may be more likely to convert e-consults conservatively due to comparatively less specialty-specific training or comfort managing complex cases. Importantly, in our system, APPs and dermatologists receive e-consults based largely on provider availability rather than clinical complexity. This reduces the likelihood that differences in patient or case characteristics explain the observed variation. Existing literature on provider-level differences in e-consult use and impact have shown mixed results. For example, one study comparing e-consults submitted by nurse practitioners and family physicians found that nurse practitioners were more likely to report that the consultation led to new clinical guidance and less likely to say it avoided an in-person referral [5]. In contrast, a systematic review of referral practices found no significant difference in overall referral rates between nurse practitioners and family physicians [6]. However, these studies largely examine differences among referring providers rather than responding providers. Because our study investigates variation among the providers performing the e-consults themselves, it represents a novel contribution to the literature. To our knowledge, no published studies have specifically examined provider-level variation in dermatology e-consult outcomes from the specialist side, underscoring the importance of our findings.

While our findings shed light on differences in provider behavior, they also raise questions about the clinical appropriateness of these conversions. Without detailed outcome data, it remains unclear whether the higher conversion rate among APPs were clinically necessary or reflective of a lower threshold for referral. Future research should explore the clinical drivers and downstream outcomes of converted e-consults, considering patient complexity, consult content, and specialty-specific considerations.

In addition to clinical impact, the higher conversion rate among APPs may have broader implications for system efficiency and resource use. Given the higher conversion rate, APP-managed e-consults may increase health care utilization, with potential cost implications for patients and health systems. Assuming a standard new patient visit billed at a level 3 or level 4 (estimated reimbursement US $120–$180 per visit), the additional ~200 appointments potentially consumed due to higher APP conversion rates translates to an estimated US $24,000–$36,000 in additional health care costs during the study period. Future work could further investigate whether these conversions lead to improved outcomes or represent avoidable costs.

This study contributes to the growing body of literature on e-consult optimization and provider practice variation. As health systems increasingly adopt team-based models of care and integrate APPs more fully into specialty workflows, ensuring consistent and effective use of e-consults across provider types will be essential. Implementing structured guidance, standardized triage protocols, and targeted training modules, particularly for APPs, may help promote more consistent decision-making and appropriate referral thresholds. Additionally, health systems may consider establishing limitations or clinical guidelines regarding the types of dermatologic conditions appropriate for independent APP e-consult management to ensure high-quality care, reduce unnecessary referrals, and minimize avoidable health care costs. By equipping all members of the care team with the tools and guidance needed to manage e-consults effectively, we can improve access, preserve specialist capacity, and enhance the overall efficiency of care delivery.

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Data Availability

All data generated or analyzed during this study are included in this published article.

Authors' Contributions

Conceptualization: DH, SN
Data curation: SN
Formal analysis: DH, SN
Investigation: DH
Methodology: DH, SN
Supervision: SN
Validation: DH, SN
Writing – original draft: DH, SN
Writing – review & editing: DH, SN

Conflicts of Interest

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Abbreviations

APP: advanced practice provider
E-consults: electronic consultations

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Public Interest in Janus Kinase (JAK) IInhibitors for Alopecia Areata: A Google Trend Analysis

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Abstract

Public interest in Janus kinase (JAK) inhibitors for alopecia areata increased following media coverage and the 2022 US Food and Drug Administration (FDA) approval of baricitinib, highlighting the need for patient education and physician guidance on appropriate indications and treatment selection for hair loss disorders.

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KEYWORDS

alopecia areata; hair loss; Janus kinase inhibitors; Google Trends; alopecia areata treatment; hair loss treatment

Introduction

Janus kinase (JAK) inhibitors are a class of medications that work by targeting and inhibiting JAK enzymes, which play a significant and diverse role in the immune system. The JAK system has been implicated in a variety of immune pathways including inflammation and autoimmunity [1]. On June 13, 2022, the US Food and Drug Administration (FDA) approved the use of a JAK inhibitor, baricitinib, commercially known as Olumiant, for adults with severe alopecia areata, an autoimmune form of hair loss [2]. Additionally, this medication was also approved for the use of severe alopecia areata in children aged 12 years and over on June 26, 2023. The objective of this study was to assess the impact of the FDA approval of the JAK inhibitor, baricitinib (Olumiant), for severe alopecia areata on public interest in JAK inhibitors for alopecia areata.

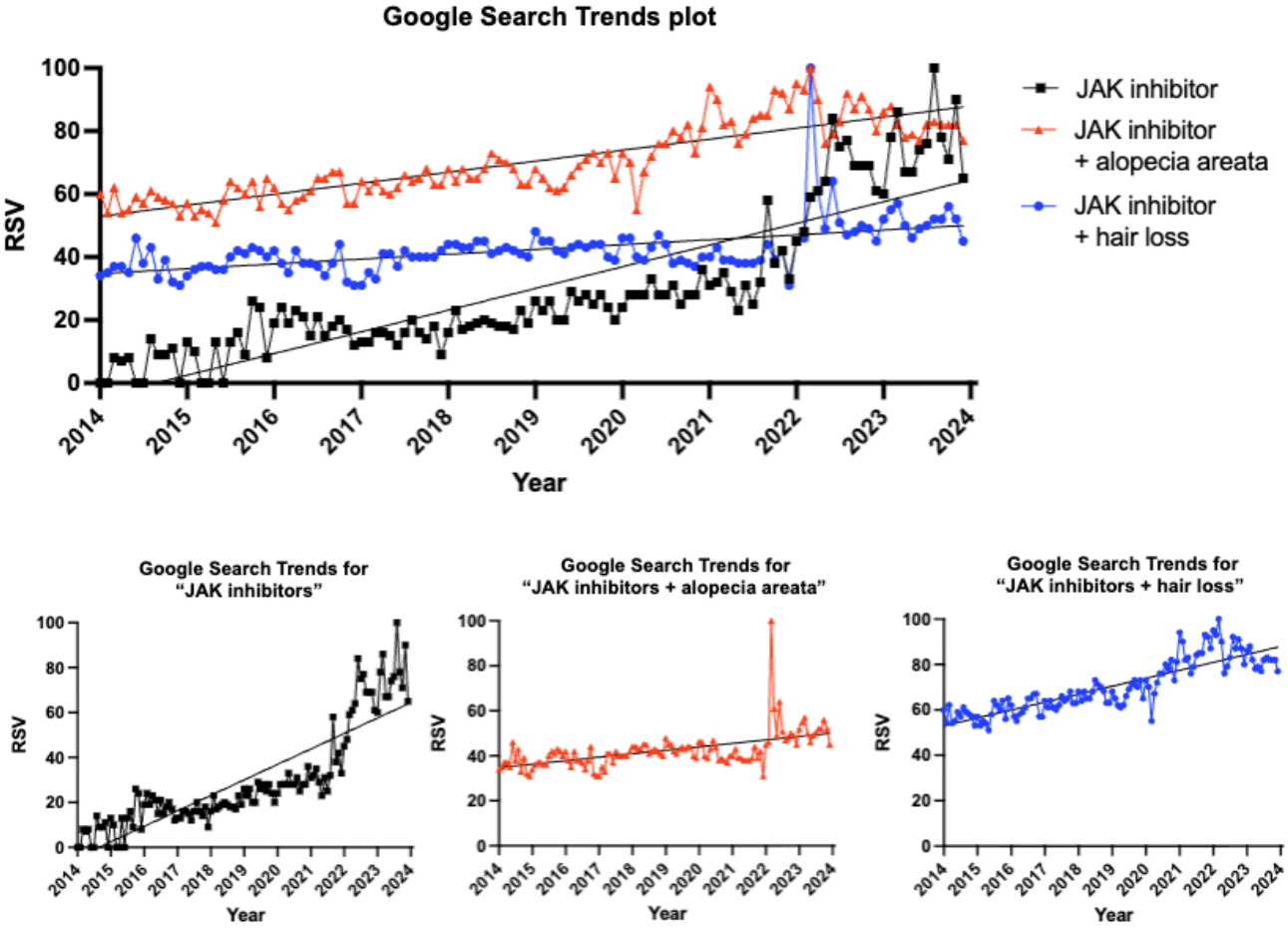
Methods

To evaluate public interest, we used Google Trends, a free analysis tool that provides insight into public interest for search terms. Google Trends calculates a relative search volume (RSV), ranging from 0 to 100. An RSV value of 0 indicates minimal interest in a keyword and a value of 100 represents the peak interest within a given period [3]. For our study, we searched the following keywords from January 2014 to January 2024: “JAK inhibitor,” “JAK inhibitor + hair loss,” and “JAK inhibitor + alopecia areata.” These keywords were chosen to encompass generic and specific terms related to the topic of JAK inhibitors and hair loss.

Results

A time series analysis was used to assess changes in RSV between January 2014 and December 2023. Linear regression demonstrated significant upward trends in RSV for all 3 search terms (Figure 1). Search interest for “JAK inhibitor” increased at a rate of 6.89 (95% CI 6.16 - 7.62; P<.001), RSV units per month with a strong model fit (R^2=0.748). Searches for “JAK inhibitor+ hair loss” also increased significantly, at a rate of 3.50 (95% CI 3.13 - 3.87; P<.001; R^2=0.749) RSV units per month. Similarly, “JAK inhibitor+ alopecia areata” demonstrated a statistically significant upward trend, though with a smaller magnitude of increase (1.54, 95% CI 1.12 - 1.96 RSV units per month; P<.001) and a more modest model fit (R^2=0.306).

Figure 1. Google Trends results for the search items "JAK inhibitor," "JAK inhibitor + alopecia areata," and "JAK inhibitor + hair loss" (data accessed April 30, 2024). Data are presented as relative search volume (RSV), where RSV of 100 represents peak search activity in a time period. The plot represents the time series analysis of Google Trends RSV per month between January 2014 and December 2023 for the terms "JAK inhibitor," "JAK inhibitor + alopecia areata," and "JAK inhibitor + hair loss." Search interest for "JAK inhibitor" increased at a rate of 6.89 (95% CI 6.16 - 7.62; P<.001; R^2=0.748) RSV units per month. Searches for "JAK inhibitor + hair loss" and "JAK inhibitor + alopecia areata" increased at a rate of 3.50 (95% CI 3.13 - 3.87; P<.001; R^2=0.749) RSV units per month and 1.54 (95% CI 1.12 - 1.96; P<.001; R^2=0.306) RSV units per month, respectively. JAK: Janus kinase.



Discussion

All 3 search terms ("JAK inhibitor," "JAK inhibitor + hair loss," "JAK inhibitor + alopecia areata") demonstrated significant increases over time (P<.001), indicating rising public interest from January 2014 to December 2023. Searches for "JAK inhibitor + hair loss" showed a strong and consistent upward trend (R^2≈0.75), while general searches for "JAK inhibitor" increased at the fastest rate, suggesting expanding overall awareness of the drug class. The increasing trend is not perfectly linear; rather, it reflects periods of spikes, drops, and plateaus. This variability is possibly influenced by social factors such as periods of media coverage, FDA approvals, etc. For example, there is an appreciable spike in all 3 search terms between 2020 - 2023, which may indicate increased public interest following increased media coverage about the FDA approval of JAK inhibitors for severe alopecia reported by news outlets as early as 2019 [4]. Baricitinib became the first FDA-approved JAK inhibitor for alopecia areata in 2022. This was followed by the approval of ritlecitinib in 2023 and deuruxolitinib in 2024 [5]. Additionally, social media applications like TikTok could be possible contributors to the increase in public interest, due to user-friendly content, the ability of content creators to freely express their journey with hair loss and JAK inhibitors, and users being able to engage in conversations with their peers anonymously. Although detailed TikTok data trends from 2014 - 2023 were not readily attainable, the TikTok Creator Search Insights tool, which provides trends for the past 6 months, indicates that more than 1 million searches were made on TikTok for JAK inhibitors and alopecia from September 2025 to February 2026. These searches yield a variety of videos, including content from patients describing their experience with JAK inhibitors. A more in-depth exploration of search trends and content on social media platforms would provide further valuable insight into the trends in public interest on this topic.

Given the increased public interest in JAK inhibitor treatment as indicated by Google Search Trends in this study, it is important that the public receives proper education regarding the implications of taking JAK inhibitors and the knowledge that JAK inhibitors are treatment for severe alopecia areata, which is an autoimmune condition, and not currently efficacious for other hair loss disorders. It is important for physicians to educate their patients on hair loss disorder treatments and increase patient awareness of certain hair loss treatments for the patient's form of hair loss.

Authors' Contributions

JH, NAHK, HI performed data analysis;
JH, NAHK, HI, LDK all contributed to manuscript preparation;
JH, NAHK, HI and LDK revised the manuscript, approved the final version, and agree to be accountable for all aspects of the work.

Conflicts of Interest

None declared.

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Abbreviations

FDA: US Food and Drug Administration
JAK: Janus kinase
RSV: relative search volume

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Chronic Facial Abscess Mimicking Cervicofacial Actinomyces From Dermal Filler Migration: Case Report

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Abstract

Dermal fillers are commonly used for facial augmentation, but delayed complications such as granulomatous inflammation and filler migration can mimic chronic bacterial infections, such as cervicofacial actinomycosis, and lead to diagnostic misdirection. We present the case of a woman aged 56 years with a chronic, draining abscess on the right cheek that persisted for 3 years and was initially suspected to represent cervicofacial actinomycosis. Tissue cultures were negative, and histopathologic analysis following excisional biopsy revealed polymethyl methacrylate microspheres and hyaluronic acid surrounded by granulomatous inflammation and reactive lymphoid aggregates, consistent with a foreign body reaction to dermal filler. The patient experienced complete resolution after surgical excision. This case underscores the diagnostic challenges posed by delayed filler complications and highlights the importance of considering prior cosmetic procedures in patients with chronic facial abscesses.

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KEYWORDS

dermal filler; foreign body reaction; facial abscess; granulomatous inflammation; filler complications; cosmetic dermatology

Introduction

The use of dermal fillers for facial augmentation has increased significantly, with both temporary (hyaluronic acid) and semipermanent or permanent fillers (polymethyl methacrylate [PMMA], calcium hydroxylapatite, silicone) [1]. While most complications occur immediately or within weeks, delayed reactions, including granuloma formation and filler migration, can present months to years after injection [2].

Foreign body granulomas are a known complication of PMMA-based fillers (Bellafill/Artefill; Suneva Medical Inc) and result from a chronic inflammatory response to nondegradable microspheres [3]. These reactions may be triggered by delayed hypersensitivity, biofilm formation, or immune dysregulation and can resemble infectious or inflammatory processes. They can also closely mimic chronic infectious processes such as cervicofacial actinomycosis, characterized by draining sinuses and subcutaneous abscesses, often prompting an extensive infectious workup before the true etiology is recognized [4]. Diagnosis relies on histopathologic evaluation, which typically reveals multinucleated giant cells, lymphoid aggregates, and fibrosis surrounding filler particles [3,4].

This case highlights the importance of early recognition of iatrogenic causes in the differential diagnosis of chronic facial abscesses and underscores the long-term risks associated with semipermanent fillers, particularly PMMA-based products. Given the varied histopathologic presentations of different filler materials, distinguishing PMMA from other injectables is crucial for accurate diagnosis and management.

Ethical Considerations

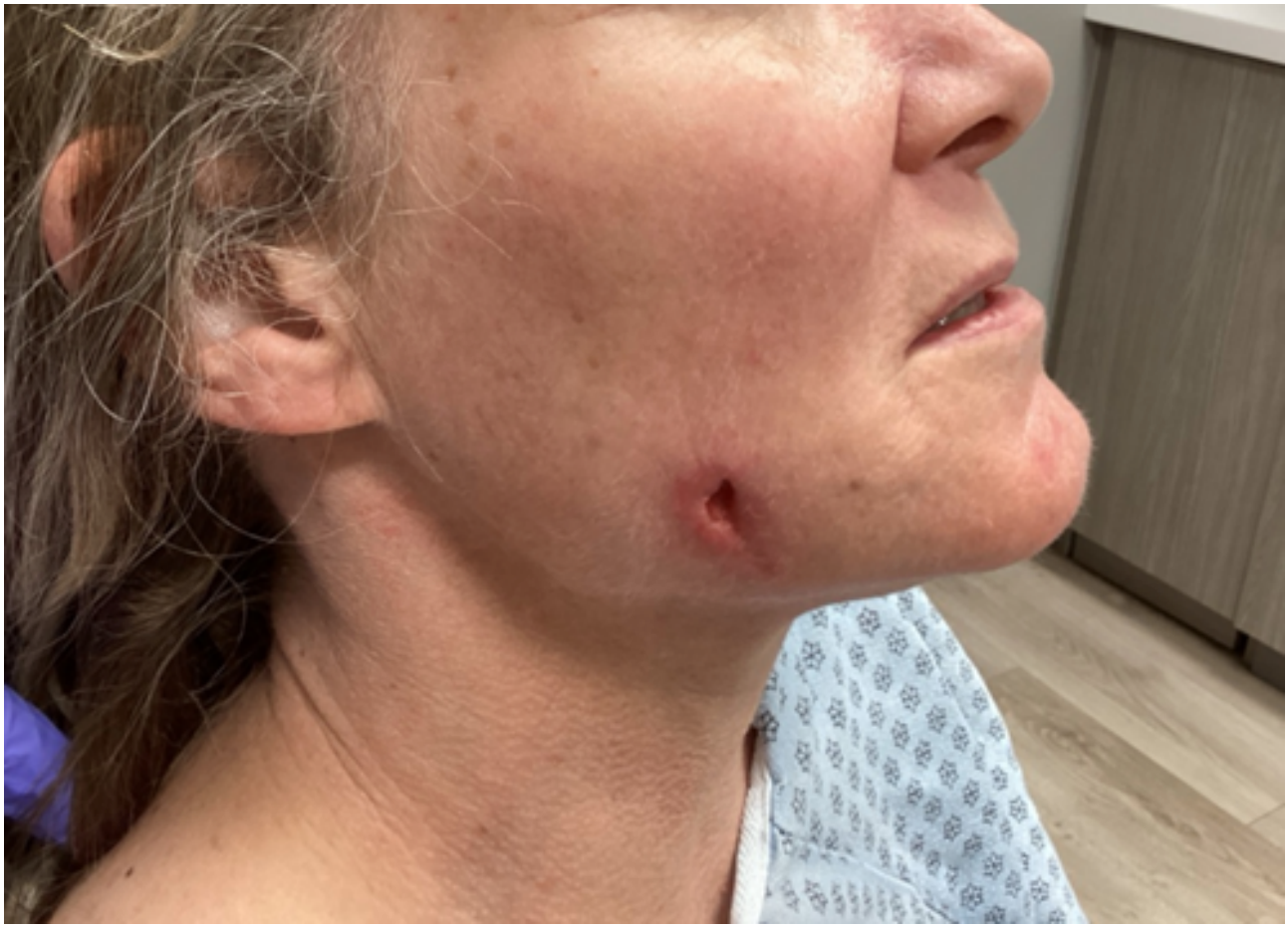
The authors obtained written consent from the patient for their photographs and medical information to be published in print and online, with the understanding that this information may be publicly available. Patient consent forms were not provided to the journal but are retained by the authors.

Case Report

A woman aged 56 years presented with a chronic, nonhealing, draining abscess localized to the right cheek. Characterized by intermittent drainage, localized tenderness, and surrounding erythema, the nodule persisted for approximately 3 years, during which time the patient sought care from specialists on at least one occasion. The patient denied systemic symptoms such as fever, chills, dental caries, oral drainage, pain with salivation, or malaise. Past medical history was noncontributory, and the patient had no known history of immunosuppression, diabetes, or recurrent skin infections.

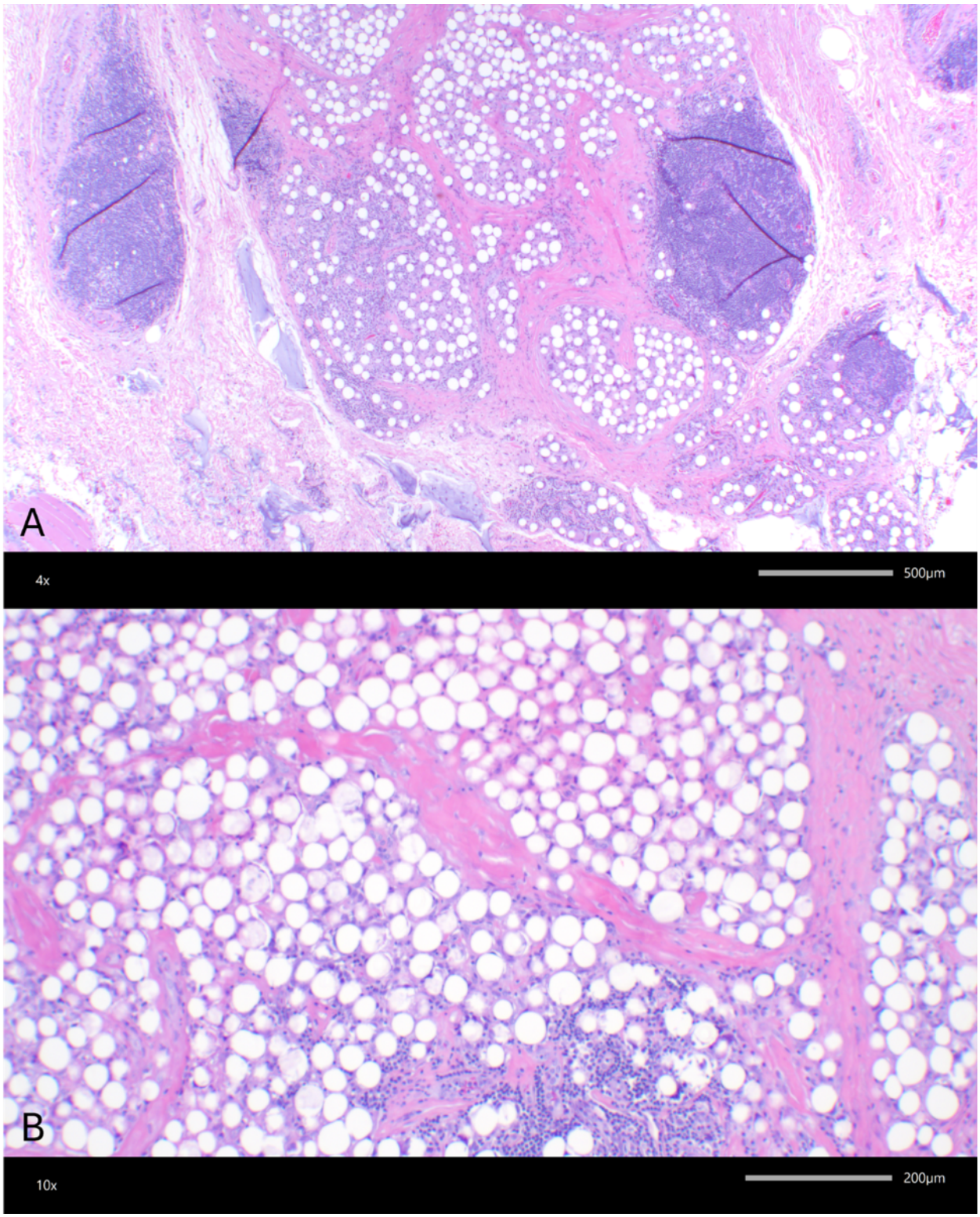
On physical examination, the deep nodule was ulcerated, with erythematous borders localized to the right inferior central malar cheek. The ulcer base exhibited crusting and purulent material, with 3 cm of surrounding induration (Figure 1). No regional lymphadenopathy was present.

Figure 1. Nonhealing ulcer with surrounding erythema and induration on the right cheek.



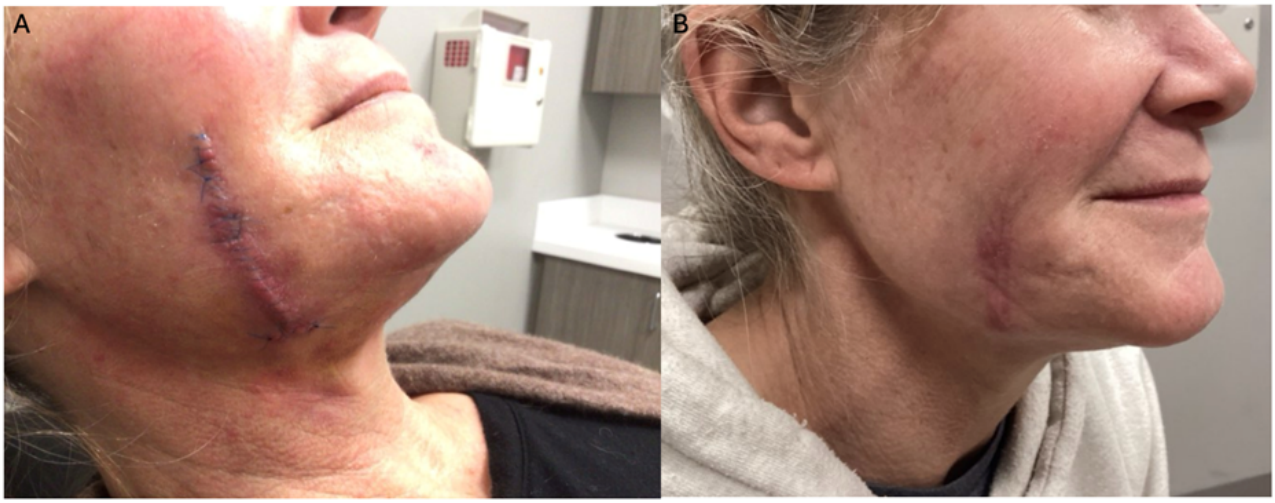
Given the persistent nature of the abscess, a tissue culture was obtained via punch biopsy, which was negative for bacterial, fungal, and atypical mycobacterial growth. Due to the size and depth of the lesion, an excisional biopsy was performed to identify potential inflammatory or neoplastic pathology. Histopathologic analysis (Figure 2) revealed foreign body granulomas with abundant reactive lymphoid tissue, along with an accumulation of PMMA microspheres and hyaluronic acid, consistent with semipermanent dermal fillers. Surrounding granulomatous inflammation was also noted. Special stains, including Grocott methenamine silver, Fite, and Gram stains, were negative for fungi, mycobacteria, and bacteria, ruling out infectious etiologies.

Figure 2. Histologic features consistent with a foreign body reaction to polymethylmethacrylate (PMMA) filler. (A) Incisional biopsy with numerous rounded vacuolated spaces, 30 - 50 µm in size, consistent with PMMA spherules and surrounding granulomatous inflammation and reactive lymphoid aggregates. Adjacent homogeneous basophilic material consistent with hyaluronic acid is also present (hematoxylin and eosin stain; 4x). (B) Higher magnification of PMMA spherules (hematoxylin and eosin stain; 10×).



The patient was seen for suture removal at 1 week (Figure 3) with an uneventful postoperative course. At 4 weeks postoperatively, the surgical site was well healed, with no signs of infection or recurrence (Figure 3). Although initially unable to recall prior dermal filler use, review of the pathology report prompted the patient to remember having received Bellafill (Suneva Medical Inc) approximately 6 years prior and Restylane (Galderma Laboratories) approximately 10 years earlier, both for treatment of acne scarring on the cheeks.

Figure 3. (A) Postoperative appearance at 1 week showing early healing. (B) Postoperative appearance at 4 weeks with complete resolution and no recurrence.



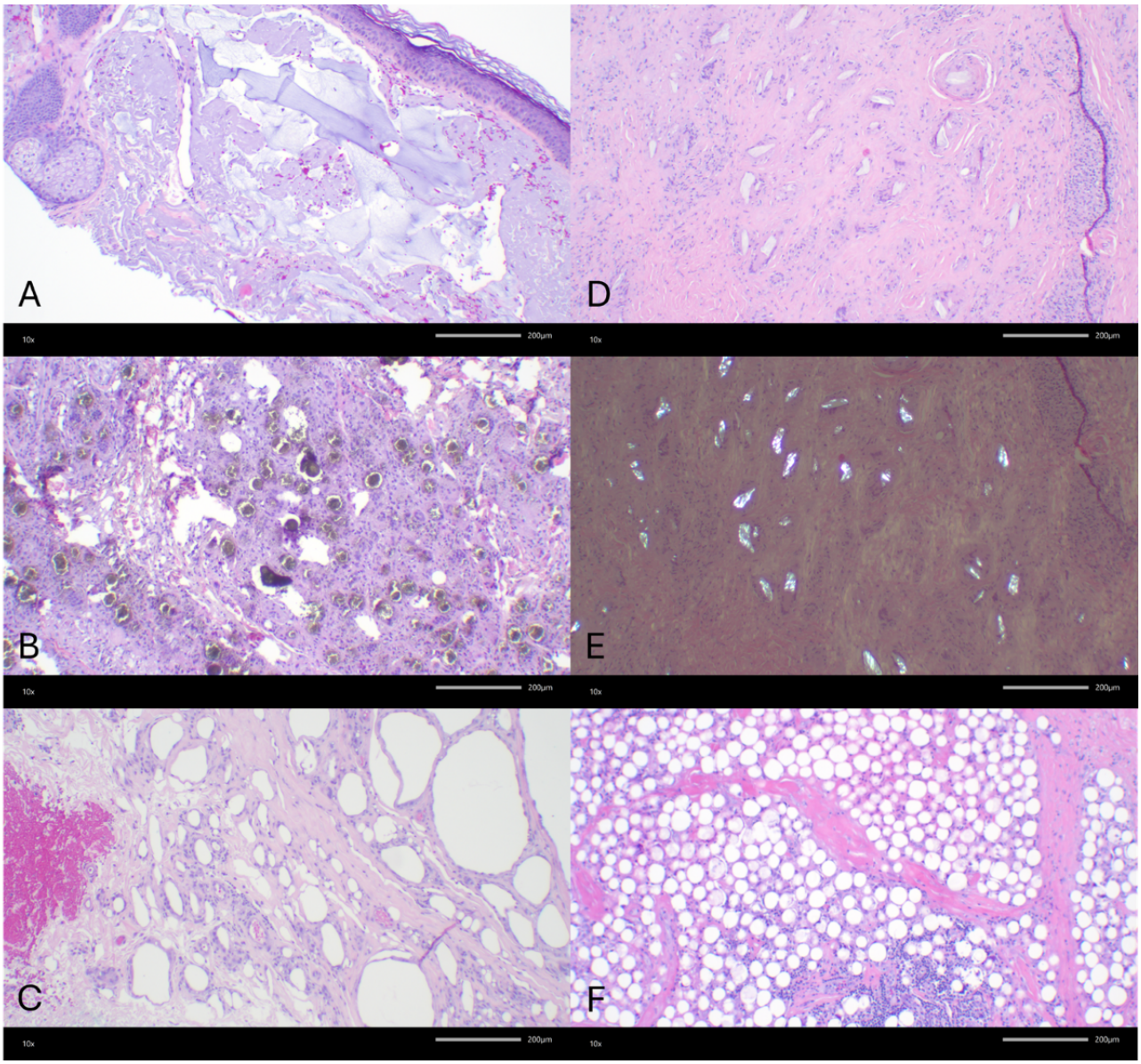
Discussion

While dermal fillers are widely used for aesthetic enhancement, their delayed complications remain an evolving area of clinical concern. Although most adverse reactions occur shortly after injection, late-onset complications can develop months to years later, often leading to diagnostic uncertainty [5]. Unlike temporary hyaluronic acid–based fillers, PMMA and other nondegradable materials persist within tissues long-term, increasing the risk of prolonged inflammatory responses [6]. The delayed presentation of PMMA-related granulomas frequently results in misdiagnosis as infection or inflammatory dermatoses, delaying appropriate intervention [7].

While complications such as filler migration and granulomatous reactions are well documented, the development of a chronic filler reaction mimicking a cervicofacial actinomycetoma is rare. Actinomycetomas are chronic, subcutaneous infections caused by filamentous bacteria, characterized by abscesses, draining sinuses, and granule production [8]. The striking clinical resemblance between the foreign body granuloma in this case and a deep-seated actinomycotic infection underscores the diagnostic challenges posed by delayed filler reactions. This case highlights the need for broad infectious and histopathologic workups in atypical, chronic soft tissue infections to prevent unnecessary antibiotic treatment and delayed surgical intervention.

Histopathologic evaluation is essential for diagnosing PMMA-related granulomas, which are characterized by multinucleated giant cells, chronic lymphohistiocytic infiltrates, and fibrosis surrounding filler particles [9]. In this case, a negative infectious workup and biopsy findings of PMMA microspheres with reactive lymphoid tissue confirmed the diagnosis and guided treatment. Management remains challenging, as PMMA-based fillers lack a reversal agent comparable to that of hyaluronic acid fillers [10]. While intralesional corticosteroid injections may offer partial improvement, surgical excision is often required for definitive diagnosis and treatment, as in this case [4]. Given the histologic variability among filler types, distinguishing PMMA granulomas from reactions to calcium hydroxylapatite, poly-L-lactic acid, and silicone is critical for guiding optimal management strategies (Figure 4).

Figure 4. Histologic features consistent with foreign body reactions to soft tissue augmentation materials. (A) Pools of wispy homogeneous basophilic material consistent with hyaluronic acid (hematoxylin and eosin; 10×). (B) Gray-green granular nonrefractile microspheres consistent with calcium hydroxylapatite with surrounding granulomatous inflammation (hematoxylin and eosin; 10×). (C) Variably sized empty lipidlike vacuoles within histiocytes consistent with silicone granuloma (hematoxylin and eosin; 10×). (D) Oval, rhomboidal, and rice-shaped clear refractile and polarizable structures consistent with poly-L-lactic acid (PLLA) particles within histiocytes (hematoxylin and eosin; 10×). (E) Polarization of PLLA fragments (hematoxylin and eosin; 10×). (F) Fairly uniform 30 - 50-µm rounded vacuolated spaces consistent with polymethylmethacrylate spherules (hematoxylin and eosin; 10×).



While PMMA fillers are used less frequently than hyaluronic acid–based products, their potential for chronic inflammatory complications requires heightened clinical awareness and a detailed risk-benefit discussion prior to injection. Semipermanent fillers pose unique challenges due to their prolonged tissue retention and risk of delayed reactions. Clinicians should maintain a high index of suspicion for foreign body granulomas and probe for a history of prior filler use in cases of chronic, nonhealing facial abscesses, particularly when standard antimicrobial therapy fails or imaging reveals localized nodularity. Following excision, patients should be informed of and monitored for delayed recurrence as well as contralateral lesions, as these may occur months to years later. This case highlights the value of histopathologic microbiologic evaluation in diagnosing facial abscesses, the limitations of nonsurgical management for PMMA-induced granulomas, and the need for increased awareness of iatrogenic factors in chronic soft tissue reactions.

Conflicts of Interest

None declared.

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Abbreviations

PMMA: polymethyl methacrylate

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Corrigenda and Addenda

Correction: Informed Consent Practices for Publication of Patient Images in Dermatology Journals

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Related Article:

Correction of: https://derma.jmir.org/2025/1/e60795

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In "Informed Consent Practices for Publication of Patient Images in Dermatology Journals" [1], the authors made one correction.

In Multimedia Appendix 1, we included a Dryad link to our raw dataset, which includes Clarivate data. We have recently learned that Clarivate's terms of use and Dryad's data reuse policy are incompatible, and we will not be able to deposit the raw data in Dryad. The raw dataset can be made available by contacting the corresponding author.

In Multimedia Appendix 1, the following text has been revised:

> *The raw dataset for this study is available for review via the Dryad platform and accessible via the following unique link:http://datadryad.org/share/k6Eiw-OfOGf0vJrxD6sOS8GC59H5SFuhtudjzHR1EH8.*

The text now reads:

> *The raw dataset for this study is available by contacting the corresponding author.*

The correction will appear in the online version of the paper on the JMIR Publications website, together with the publication of this correction notice. Because this was made after submission to PubMed, PubMed Central, and other full-text repositories, the corrected article has also been resubmitted to those repositories.

Multimedia Appendix 1
List of the top 50 dermatology journals ranked by the 2023 Clarivate Journal Citation Report and a link to the publicly available raw dataset used in the study.
[DOCX File , 17 KB - derma_v9i1e94194_app1.docx]

Reference

1. Taiwo T, Obiakor B, McClung S, Shinkai K. Informed Consent Practices for Publication of Patient Images in Dermatology Journals. JMIR Dermatol 2025 Apr 18;8:e60795 [FREE Full text] [doi: 10.2196/60795] [Medline: 40249653]

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AI and Digital Tools in Dermatology: Addressing Access and Misinformation

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Abstract

Digital dermatology, which is defined as the use of digital technologies that leverage individual- and population-level skin data to improve the diagnosis, treatment, and prevention of skin diseases, has emerged as a critical frontier for bridging persistent gaps in dermatologic care. This transformation holds particular promise for addressing long-standing inequities linked to geography, income, and skin type. According to the Global Burden of Disease 2023 study, skin and subcutaneous diseases remain among the most prevalent global health conditions, contributing substantially to disability-adjusted life years. Digital tools (including teledermatology, artificial intelligence [AI], and large language models) offer new ways to extend diagnosis, education, and patient empowerment to historically underserved populations. However, these same innovations risk amplifying disparities if they are not designed and deployed intentionally. Algorithmic bias, uneven digital access, and the absence of culturally responsive models can undermine progress. In this conceptual and narrative review, we draw on expert dialogues and illustrative literature, including multistakeholder exchanges at the *Skin and Digital Summit (2023-2025*) and related global forums, to examine how digital dermatology can promote equitable skin health. We focus on 3 interlinked priorities: expanding access through scalable digital platforms, ensuring AI fairness via comprehensive and diverse datasets, and countering dermatological misinformation. Central to the latter is a bot concept described here as a dynamic cycle that analyzes scientific literature; ranks evidence; translates complex research into clear language; and delivers trustworthy, personalized guidance to both consumers and clinicians. By embedding expert oversight and evidence prioritization, such tools can ensure that accurate, actionable information reaches users at the speed and scale of the internet. Drawing on case studies (including lessons from the World Health Organization's AI skin health app) and insights from the Skin and Digital Summit, we highlight both the transformative potential and the ethical complexities of these digital solutions. To navigate this evolving landscape, we propose the concept of radical dermatology**,** which confronts the reality that big tech is reshaping skin health whether we like it or not and insists that dermatologists and stakeholders lead the transformation through bold collaboration and unwavering clinical relevance.

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KEYWORDS

digital dermatology; AI in health care; global health; teledermatology; artificial intelligence; AI; large language model; LLM; health tech; skin; dermatology; digital health; misinformation; ethical AI; radical dermatology; social media

Introduction

Globally, skin and subcutaneous diseases are among the most common health conditions. In 2019 alone, there were an estimated 4.86 billion new cases globally, with fungal (34%) and bacterial (23%) infections making up the majority of cases [1]. Skin conditions accounted for nearly 43 million disability-adjusted life years, a burden that is both physically and psychosocially disabling [1].

Despite this high burden, dermatologic care remains inaccessible for many. An estimated 70% of people living with chronic skin diseases, including psoriasis and rosacea, do not receive professional medical care, largely due to limited dermatology workforce capacity, cost barriers, geographic distance, and sociocultural factors in care delivery [2]. These barriers affect both low-resource settings and underserved communities in low-, middle-, and high-income countries [3].

At the same time, rapid smartphone penetration, the maturation of generative artificial intelligence (AI) tools, and the World Health Organization's (WHO) prioritization of skin health have created an unprecedented window for digital solutions. Digital dermatology refers to the application of digital technologies and skin-related data (including telemedicine, mobile health [mHealth], AI, and digital imaging) to improve the diagnosis, treatment, and prevention of skin diseases. While it offers opportunities to bridge persistent gaps in access to care, challenges such as bias in algorithms, limited infrastructure, and variable digital literacy must be addressed through deliberate equity-focused design and governance. Unlike traditional models that rely on in-person specialist visits concentrated in urban centers, digital dermatology can decentralize expertise, shorten wait times, enable earlier diagnosis, extend specialist reach, and support patient self-management across geographies [4]. However, equity is not guaranteed. If bias goes unaddressed, if infrastructure remains weak, or if digital literacy lags, digital dermatology may deepen the very divides it seeks to close. In the following sections, we highlight strategies to counter these risks and to align innovation with equity.

This conceptual and narrative review synthesizes expert insights, stakeholder dialogue, and illustrative case examples to explore equity-centered strategies in digital dermatology. Input was drawn from international experts through 4 panels and 3 roundtables at the Skin and Digital Summit held virtually (IMCAS, December 2024) and in Paris (IMCAS, January 2025) [5]. Data were captured through structured notes and partial transcripts and then analyzed using inductive thematic coding by 2 reviewers, with disagreements resolved by consensus and findings organized through framework synthesis [6,7].

As discussions occurred in public professional forums, institutional review board approval was not required. Any direct speaker quotations were deidentified or quoted with permission, and related files were stored securely with restricted access, in compliance with data protection best practices.

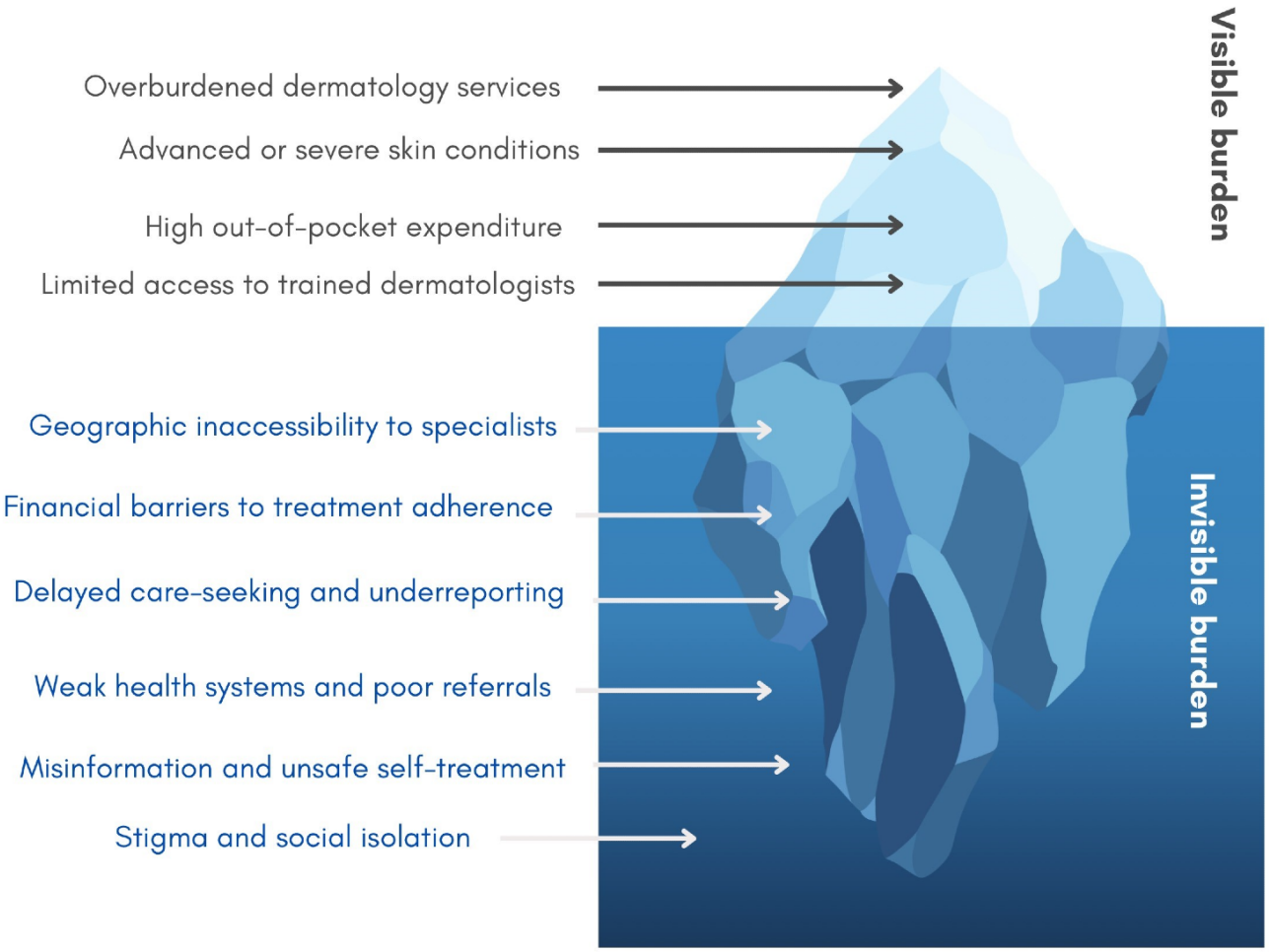
To complement these expert perspectives, we conducted a targeted literature review (PubMed, Scopus, and Web of Science; English-language studies), including studies on equity, implementation, and ethics in digital dermatology and related fields, thereby reducing selection bias.

We discuss the WHO-neglected tropical disease mobile app as an example of ongoing implementation efforts and insights from global experts with references, where applicable. These examples were selected to highlight emerging real-world dynamics that are not yet captured in peer-reviewed literature. A narrative approach was used to thematically analyze insights across the digital dermatology continuum involving access to dermatologic care through digital innovation, datasets in dermatology, and combating skin-related misinformation.

Expanding Access to Dermatologic Care Through Digital Innovation

Despite the global burden of skin disease, dermatologic care remains underprioritized. Structural barriers, workforce shortages, and high out-of-pocket costs continue to limit access, especially in underserved and rural areas (Figure 1). These challenges are particularly acute for skin of color and populations in low- and middle-income countries [8,9].

Figure 1. The iceberg phenomenon of dermatologic care disparities.



Digital health innovations, including teledermatology, AI-assisted diagnostics, and mHealth apps, are increasingly recognized as promising tools to improve dermatology service delivery and care for all [10]. Given its reliance on visual diagnosis, dermatology makes it more amenable to remote care compared with many other specialties. High-quality clinical images and contextual data can enable remote triage, diagnosis, and follow-up, offering an opportunity to decentralize expertise [11,12].

One area is the proliferation of consumer-facing dermatology apps that offer mole monitoring, acne advice, and other self-assessment tools for timely triage and basic education, particularly in contexts where specialist access is limited. A 2024 review identified more than 900 such apps, including 41 with AI capabilities, and found their performance to be variable [13]. A 2021 analysis also showed sensitivity for melanoma to be highly variable across top apps, often with little dermatologist oversight or regulatory validation [14].

Alongside commercial tools, institutional efforts are advancing [15]. In 2024, the WHO piloted an AI-assisted mobile app across 5 Kenyan counties to help frontline workers identify 13 neglected tropical diseases and 24 common skin conditions. Forty Ministry of Health workers captured 605 patient images, which were reviewed by dermatologists. Although formal peer-reviewed accuracy data are pending, preliminary findings indicate more than 80% diagnostic agreement and strong usability for triage purposes rather than as a diagnostic replacement. Importantly, the app includes offline functionality and multilingual support and design features critical for resource-limited contexts [16,17]. However, several infrastructural and regulatory barriers persist as challenges, including unstable networks, device costs, limited digital literacy, and fragmented data governance frameworks that constrain uptake [18]. In some regions, legal restrictions on data sharing further complicate deployment. Addressing these challenges will require coordinated public-private partnerships and context-specific policy support.

Additionally, we must acknowledge that although digital dermatology tools can improve diagnosis and education, their impact is limited if patients cannot access the medications they are prescribed. In underserved areas, medication shortages, high costs, and weak supply chains often prevent timely treatment. Closing gaps in dermatologic care requires strategic, multisector partnerships to ensure that digital solutions are not just short-term pilot projects, but long-lasting, locally led interventions supported by active partnerships with big tech and big pharma [19]. To strengthen implementation, policy levers such as teledermatology reimbursement and data protection standards must be embedded within digital health initiatives. Such initiatives must work in tandem with public health systems, with continued monitoring of program success (such as shorter time to treatment after digital triage), through demand forecasting, community health worker training, and pharmacy

partnerships for sustained equitable access to both diagnosis and treatment [20].

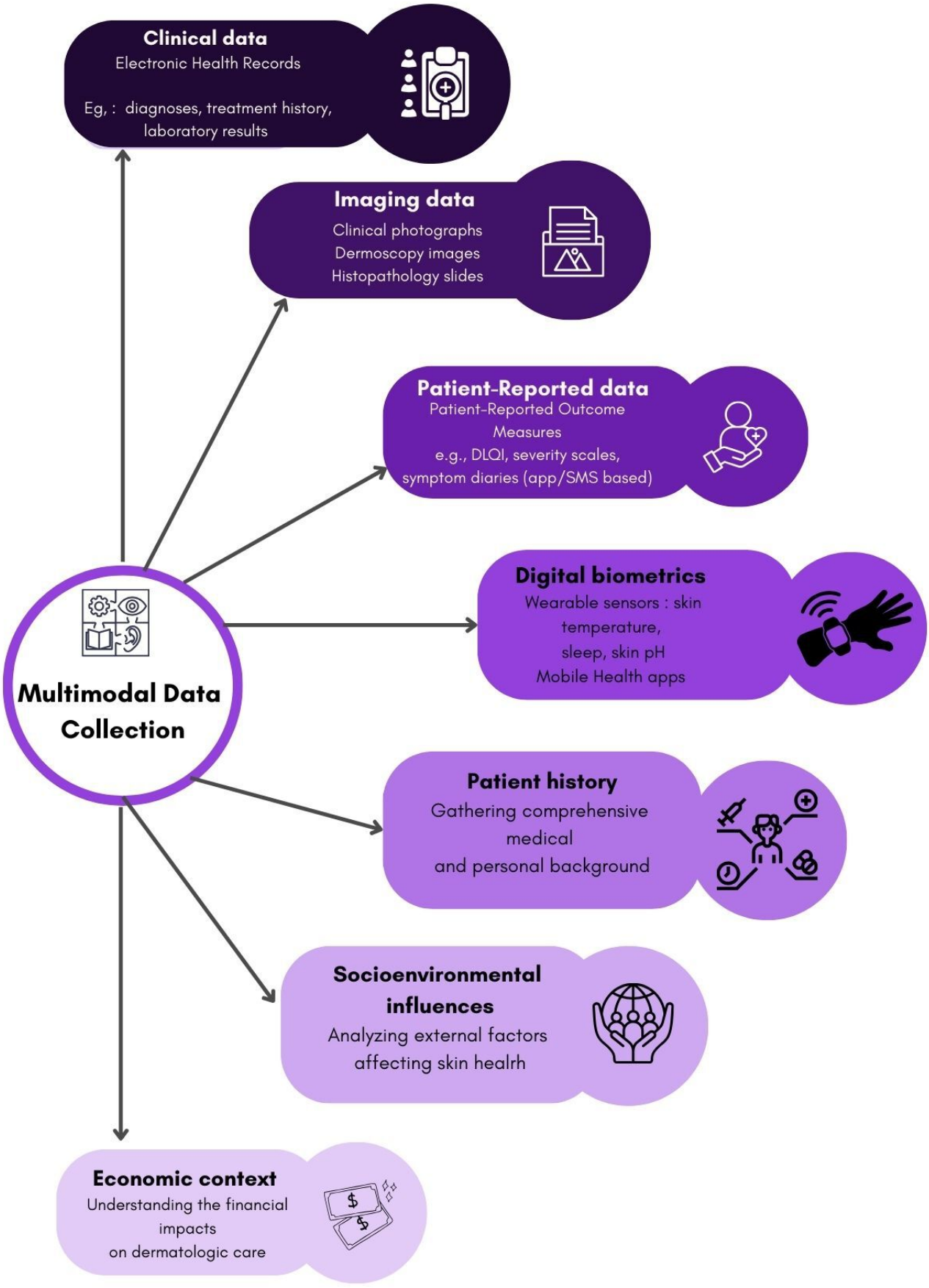
Datasets: The Key to Unlocking AI Potential in Dermatology

Complementing access-focused interventions, the success of AI in digital dermatology hinges on one critical factor: data. Dermatologic AI systems predominantly rely on visual data, including clinical photographs and dermatoscopy images, for training and validation [21]. However, the lack of large, diverse, and representative datasets poses a major limitation [22]. Most existing datasets overrepresent light-skinned patients from high-income settings and focus heavily on conditions such as melanoma [23]. Even newer collections, such as the Diverse Dermatology Images dataset, while addressing skin tone gaps, are limited in diagnostic breadth and geographic diversity [24,25]. To strengthen fairness and reproducibility, skin tone annotation should evolve beyond the traditional Fitzpatrick phototypes toward newer scales such as the Monk Skin Tone scale, using standardized labeling and consistent documentation protocols across datasets [26].

Without datasets that reflect all segments of the population and systems that ensure access to recommended care, AI solutions may offer precise diagnoses that are ultimately inaccessible to those who need them most. Relying on single-modality datasets, such as static images alone, restricts the ability of AI systems to capture the real-world complexity of dermatological care [27]. Dermatologic decision-making is not merely visual; it involves psychometric, environmental, and cultural factors. For instance, 2 patients with the same lesion may receive different treatment recommendations depending on their medical history, stress levels, socioeconomic context, or cultural expectations.

To address these issues, a multimodal data approach is essential (Figure 2) [28]. This includes integrating clinical photographs with patient histories, self-reported outcomes, environmental exposures, and behavioral data. For example, in conditions such as psoriasis or vitiligo, combining lesion photographs with validated severity indices (eg, Dermatology Life Quality Index and Pruritus Numerical Rating Scale), environmental parameters (UV index and humidity), comorbidities, and adherence telemetry can yield more personalized, context-aware interventions. These inputs can be captured via mHealth apps and wearables [29,30]. AI models trained on such holistic datasets, encompassing lesion images, lifestyle habits, stress levels, and treatment adherence, can deliver more accurate, individualized care. Importantly, these insights must be coupled with robust privacy safeguards, including on-device data processing and granular patient consent. Furthermore, to translate these innovations into improved outcomes in underserved areas, they must be linked to reliable access to medications through community health workers, local pharmacies, or public-sector distribution programs.

Figure 2. Expanding dermatology with multimodal data.



Enabling this shift requires interoperable and transparent data infrastructure with an emphasis on terminology mapping and handling of metadata. Platforms such as OpenMHealth, Apple HealthKit, and Fast Healthcare Interoperability Resources–compliant electronic health records can help structure and standardize multimodal data [31]. Future

dermatology-specific tools must enable seamless integration of patient-reported outcomes and subjective (eg, pruritus scores) and objective (eg, lesion photos) metrics while ensuring data privacy. Ethical development and deployment of such AI tools must follow established frameworks such as FATE (fairness, accountability, transparency, and ethics) [32] and the OECD AI Principles [33]. These frameworks call for human oversight, robust transparency about model limitations, and equitable access to benefits. Poorly curated or biased data can not only reduce diagnostic accuracy but also worsen outcomes for already marginalized groups.

While appealing, the belief in autonomous, data-driven AI-based decision-making has significant limitations; data alone are not the answer. Although increasing data volume often enhances predictive accuracy, the quality and representativeness of the datasets remain crucial [34]. Poorly curated data can reinforce existing biases and, in some cases, worsen clinical outcomes [35]. Human clinicians inherently recognize that accurate interpretation of data requires understanding its context, particularly in dermatology, where the psychosocial impact of visible skin conditions demands sensitivity beyond numerical analysis alone [36]. Effective dermatological decision-making thus integrates objective data with patient-specific considerations, including emotional, social, and cultural factors. Identical skin lesions may necessitate different diagnostic or therapeutic approaches depending on individual patient circumstances and preferences, underscoring the necessity of collaboration between data-driven insights, clinical expertise, and patient perspectives.

Combating Skin-Related Misinformation

Maximizing the impact of digital dermatology also requires confronting the parallel crisis of misinformation [37]. Fueled by algorithmic amplification and low digital health literacy, skin-related myths such as “sunscreen causes cancer” or “natural remedies are always safer” spread faster than verified medical guidance [38]. Platforms that reward engagement often privilege sensational content over accuracy, and dermatology is no exception. This dynamic is compounded by the low visibility of authoritative voices: only 4% of dermatology influencers on Instagram are board-certified dermatologists, and on TikTok, more than one-third of dermatology-related videos are created by nonprofessionals [39], frequently promoting unverified treatments such as raw potatoes for acne. On Reddit [40] and other forums, patients increasingly crowdsource diagnoses—sometimes for sensitive conditions such as sexually transmitted infections—reflecting growing distrust in formal health care and a shift toward peer-based digital health advice [41]. Studies of parenting blogs have shown that posts containing sunscreen misinformation consistently receive more engagement than scientifically accurate content [42].

Efforts to counter this phenomenon must go beyond reactive myth-busting and instead adopt structured, measurable, and trust-centered approaches and strategies grounded in successful digital literacy campaigns [43]. Public health initiatives in adjacent domains offer useful models. For example, the WHO’s “Pause Before You Share” campaign effectively encouraged users to reflect before forwarding unverified information during the COVID-19 pandemic [44]. The United Nations Children’s Fund and Gavi’s #VaccinesWork initiative combined localized messaging with influencer partnerships to rebuild vaccine confidence [45]. In sexual health, the AI-powered chatbot “Roo,” developed by Planned Parenthood, has demonstrated how conversational interfaces can deliver reliable, age-appropriate, and stigma-free health information at scale [46]. These campaigns share a common thread: they prioritize trust, accessibility, and proactive engagement, principles replicable in dermatology.

Drawing inspiration from these models, we propose an AI-powered dermatology chatbot (still in its conceptual phase) designed to address misinformation while empowering users with accurate, evidence-based content. The chatbot would operate on a retrieval-augmented generation architecture, fine-tuned on dermatology-specific content. It would draw from validated sources such as Cochrane systematic reviews, the American Academy of Dermatology (AAD), and the European Academy of Dermatology and Venereology (EADV) guidelines, patient association websites, and public health repositories from the WHO and CDC (Centers for Disease Control and Prevention). To ensure scientific rigor, the chatbot would internally rank information using the GRADE (Grading of Recommendations, Assessment, Development and Evaluations) framework. It would also include medical disclaimers, clinician escalation paths, hallucination checks, and refusal policies for diagnostic or treatment queries. Bias testing**,** data minimization**,** and content updates aligned with AAD and EADV guidelines would maintain fairness, privacy, and accuracy. Its performance should be tracked through reach, engagement, accuracy, harmful-advice rate, and user trust metrics. Dermatologists should lead content creation and partnerships to amplify credible, evidence-based information [47].

It is crucial to reiterate that dermatologists need to proactively develop accurate digital content to combat the spread of misinformation [48]. This can involve structured social media initiatives such as verified content series, myth-busting reels, or question-and-answer sessions on platforms where misinformation is most widespread. Collaborating with trusted influencers, patient advocacy groups, or public health campaigns can further expand reach and ensure that evidence-based information is both accessible and engaging [49].

Beyond Content Curation: Developing a Technological Solution to Address Skin Misinformation

The rapid, unchecked spread of skin-related misinformation is emerging as a significant public health concern—one that no dermatologist, no matter how dedicated, can tackle alone [48-51]. In this digital era, where falsehoods travel faster than facts, expert voices must be amplified by bold technological innovation. What is urgently needed is not just another fact sheet, but an intelligent, real-time solution: an AI-powered dermatology conversational agent (Figure 3) capable of delivering science-backed answers at the speed of the internet

[52]. This chatbot could serve as a critical tool, helping to dispel myths, provide accurate information, and guide individuals toward appropriate care, with empathy [53].

Figure 3. Cycle of artificial intelligence (AI)–powered dermatological chatbot. LLM: large language model; ML: machine learning; NLP: natural language processing.

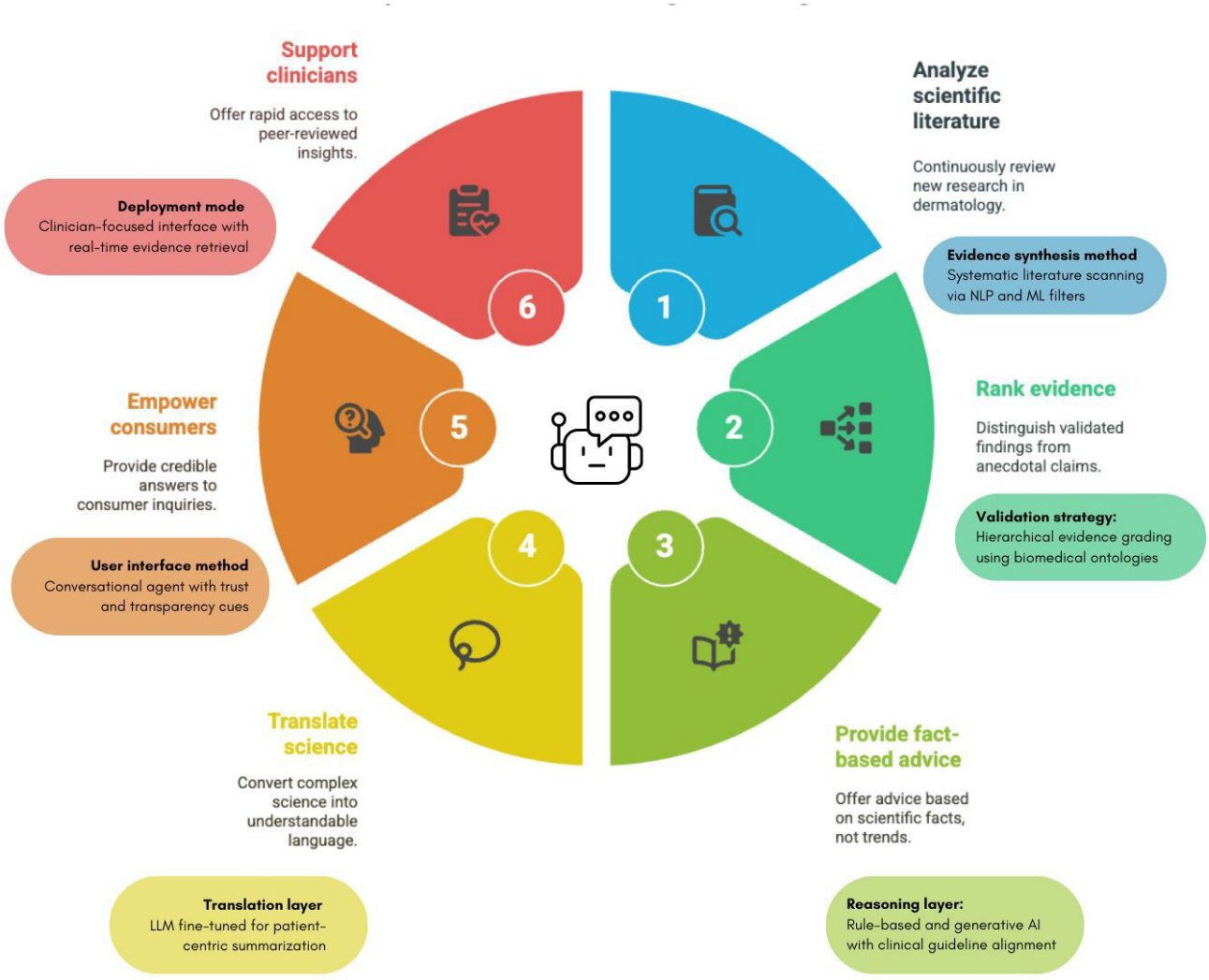


Figure 3 outlines the engine behind such a tool—a dynamic cycle that analyzes scientific literature, ranks evidence, translates complex research into clear language, and delivers trustworthy, personalized guidance to both consumers and clinicians. This is not just an upgrade; it is a paradigm shift, and it demands a multidisciplinary alliance of dermatologists, AI developers, skin scientists, tech experts, and health communicators. Only together can we build the digital frontline dermatology desperately needs.

The concept of "radical dermatology" underscores this transformation. Radical dermatology refers to a future-oriented framework that calls on dermatologists and skin health stakeholders to actively lead, rather than passively follow, the digital transformation of their field. It recognizes the growing influence of big tech in reshaping skin health and emphasizes that dermatologists must drive this change through bold collaboration, clinical relevance, and one that is ethically governed through measures such as equity dashboards and data diversity thresholds.

While conceptual in origin, radical dermatology lays the groundwork for concrete steps such as pilot studies, comparative evaluations of AI- and clinician-led care, and assessments of cost-effectiveness and equity outcomes. However, limitations of this paper include its presentation of a conceptual framework and a hypothetical chatbot model, with insights derived exclusively from expert dialogue rather than empirical clinical trials. To advance this research, future work should aim at pilot studies across diverse populations, comparative analyses of AI-supported versus clinician-led care, and comprehensive cost-effectiveness research. Dermatologists must play a central role in leading this transformative shift, guiding not only the application of digital tools but also their fundamental design, rigorous testing, and governance. This crucial role requires dermatologists to do more than just use digital tools; they must actively shape the technological, ethical, and societal landscape of digital dermatology.

Conclusions

Leveraging individual- and population-level skin data ethically through the convergence of computer vision, mHealth, and generative AI presents a pivotal opportunity for dermatology.

Conversational tools such as dialogic AI or chatbots, when well designed, can interpret validated evidence, provide real-time responses, and deliver guidance in ways that are accessible, accurate, and empathetic [52,53]. This is particularly relevant in dermatology, where care is visual, is time sensitive, and depends heavily on patient education and reassurance.

The promise of digital dermatology will only be achieved if these tools are developed for everyone, with transparency, accuracy, and trust as core principles and with an emphasis on ongoing safety auditing. People without access to dermatology care or reliable information stand to gain the most, provided their needs are addressed from the outset. Deployment should therefore prioritize underserved users through multilingual interfaces, offline functionality, and low-bandwidth design as integral components of equity-centered implementation. Dermatologists must remain central to this process, guiding design, overseeing implementation, and setting ethical standards to ensure that digital solutions are clinically sound and culturally appropriate.

The future of dermatology will be shaped not by algorithms alone but through collaboration among clinicians, technologist researchers, policymakers, and patients to ensure technology meaningfully advances skin health for all.

Data Availability

The datasets generated or analyzed during this study are available from the corresponding author on reasonable request.

Conflicts of Interest

None declared.

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Abbreviations

AAD: American Academy of Dermatology
AI: artificial intelligence
CDC: Centers for Disease Control and Prevention
EADV: European Academy of Dermatology and Venereology
FATE: fairness, accountability, transparency, and ethics
GRADE: Grading of Recommendations, Assessment, Development and Evaluations
mHealth: mobile health
WHO : World Health Organization

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Beta-Alanine and Aquagenic Pruritus: Proposed Neuroimmune Mechanism

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Abstract

Aquagenic pruritus (AP) is a rare itch disorder with limited effective treatments, and emerging clinical observations suggest that oral β-alanine may reduce symptoms. The purpose of this viewpoint is to propose a biologically plausible mechanism through which β-alanine may alleviate primary AP. We reviewed published case reports and patient-reported survey data describing β-alanine use in AP and integrated these clinical observations with experimental data on MAS-related G protein–coupled receptor D (MrgprD)–expressing sensory neurons and their role in mast-cell regulation. Published case reports describe marked improvement in water-induced pruritus following prophylactic oral β-alanine administration, and a recent survey of patients with idiopathic AP reported substantial symptom relief among β-alanine users. Preclinical data indicate that MrgprD-neuronal glutamate release suppresses mast cell hyperresponsiveness, suggesting a potential pathway for the observed antipruritic effect. Additional mechanisms, including β-alanine metabolism to carnosine and its potential mast cell–stabilizing effects, may also contribute. β-alanine may act through modulation of a nonhistaminergic neuroimmune circuit and represents a promising therapeutic candidate for further investigation in AP.

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KEYWORDS

aquagenic pruritus; beta-alanine; primary aquagenic pruritus; MrgprD; nonhistaminergic itch; mast-cell hyperresponsiveness; neuroimmune signaling; glutamatergic signaling; pruriceptive pathways; neurocutaneous mechanisms; itch modulation; MAS-related G protein–coupled receptor D

Aquagenic pruritus (AP) is a rare skin disorder characterized by intense itching, tingling, or burning after contact with water, which can significantly impact an individual's quality of life [1]. Although AP is classically associated with polycythemia vera, idiopathic (primary) AP likely represents the most common form in the general population [2]. Therapeutic approaches to alleviate this condition remain challenging and often ineffective. Existing treatments primarily focus on symptom relief through topical emollients, phototherapy, antihistamines, and avoidance of water exposure, but they provide only partial relief and do not address the underlying mechanisms triggering the pruritus [1].

The pathogenesis of idiopathic AP is incompletely understood. Several mechanisms have been proposed, including abnormal mast cell activation, dysregulated cutaneous nerve signaling, and altered neuroimmune communication within the skin [3]. A small biopsy study found increased acetylcholinesterase activity in eccrine-associated nerve fibers after water exposure in patients with AP and polycythemia vera, suggesting increased acetylcholine release and possible involvement of eccrine-associated pathways in AP pathogenesis [4]. AP has also been described in familial cases, suggesting a potential genetic predisposition [1].

Recent case reports have shed light on the role of β-alanine, a nonessential amino acid, in modulating the sensation of itch. β-alanine is a known agonist at the pruriceptive receptor MAS-related G protein–coupled receptor D (MrgprD) and induces a weak nonhistaminergic itch in humans and mice [5]. A survey-based study investigating β-alanine supplementation among 75 patients with idiopathic AP reported that 70.7% of participants who used β-alanine described substantial symptom relief, with an average relief score of 8.84 out of 10 (95% CI 8.52 - 9.16) [6].

In one case report, a 33-year-old adult male with primary AP found that prophylactic oral β-alanine taken 5 to 15 minutes before water exposure markedly reduced pruritus with sustained improvement at the 20-week follow-up [5]. In a second case, a 16-year-old male with AP refractory to traditional treatments

also found relief from oral β-alanine taken prior to water exposure [7].

In these reports, β-alanine was administered orally in powder form [5,7]. Survey data suggest that patients most commonly use doses averaging approximately 1.59 g per day during acute exacerbations. In this survey, 66% of users preferred powder formulations and 73.6% reported taking β-alanine on an as-needed basis [6].

The mechanism responsible for this improvement is unknown, and because MrgprD activation is typically pruritogenic, the antipruritic effect is unlikely to result from direct receptor agonism. Other mechanisms may also contribute to the observed therapeutic benefit. For example, β-alanine is a precursor to carnosine, a dipeptide with antioxidant and intracellular pH-buffering properties that may help stabilize mast cell responses. These effects could complement or act independently of MrgprD-mediated neural pathways [6].

Although the mechanisms underlying primary AP are not fully established, the delay between water exposure and itch onset reported in many patients may suggest a nonhistaminergic process involving abnormal neuroimmune interactions between sensory afferents and epidermal or immune cells such as keratinocytes, basophils, or mast cells [5]. A mouse study from 2021 demonstrated that MrgprD-expressing cutaneous sensory neurons help maintain skin homeostasis by releasing glutamate, which dampens mast cell hyperresponsiveness [3]. One possibility is that β-alanine may transiently enhance MrgprD-neuronal activity enough to increase local glutamate release, thereby strengthening this homeostatic inhibitory circuit. In primary AP, where mast cell hyperresponsiveness and nonhistaminergic pathways are suspected, enhanced MrgprD-mediated glutamatergic signaling could suppress mast cell activation and reduce downstream pruriceptive input. Recent work from the same research group further supports this model by demonstrating that glutamate can act directly on both mouse and human mast cells to suppress their activation, reinforcing the potential role of glutamatergic signaling in cutaneous immune homeostasis [8].

Available patient-reported data suggest that β-alanine is generally well tolerated, with transient paresthesia being the most frequently reported side effect. This is consistent with the known safety profile of β-alanine in sports nutrition studies and is typically mild and self-limited. Importantly, 90% of surveyed users reported sustained therapeutic benefit without loss of efficacy over time, suggesting minimal tachyphylaxis [6,9].

Although speculative, this mechanism aligns with both the delayed nature of AP symptoms reported by some individuals and the observed clinical benefit of prophylactic β-alanine administration. Given the debilitating nature of AP and the scarcity of effective therapies, the emerging evidence supporting β-alanine as a fast-acting, well-tolerated, inexpensive, and accessible intervention is noteworthy.

We encourage further controlled studies to characterize optimal dosing, duration of effect, long-term safety, and the underlying neurocutaneous mechanisms. If β-alanine consistently alleviates symptoms in primary AP, this observation may also support the concept that non–FcεR-mediated mast cell activation and neuroimmune dysregulation play important roles in disease pathogenesis.

β-alanine may represent a promising therapeutic avenue for a condition that currently lacks reliable treatment options. These observations highlight the need to further explore β-alanine as a targeted modulator of nonhistaminergic itch pathways in primary AP.

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Conflicts of Interest

None declared.

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Abbreviations

AP: aquagenic pruritus
MrgprD: MAS-related G protein–coupled receptor D

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