International Journal of Dermatology

International Journal
of Dermatology

REVIEW ARTICLE OPEN ACCESS

Psoriasis in People With Skin of Color: An Evidence-Based Update

Maria-Angeliki Gkini[1] | Mio Nakamura[2] | Andrew F. Alexis[3] | Angela Londoño-Garcia[4] | Peter C. M. van de Kerkhof[5] | Nejib Doss[6] | Christopher E. M. Griffiths[7,8] | Bridget Kaufman[9] | Christine E. Kleyn[7,8] | Mark Lebwohl[10] | Jan S. Redfern[11] | Junko Takeshita[12,13] | Murlidhar Rajagopalan[14] | Mahira H. El Sayed[15]

[1]Department of Dermatology, Royal London Hospital,Barts Health NHS Trust, London, UK | [2]Department of Dermatology, University of Michigan, Ann Arbor, Michigan, USA | [3]Department of Dermatology, Weill Cornell Medicine, New York, New York, USA | [4]Department of Dermatology, CES University, Medellin, Colombia | [5]Department of Dermatology, Radboud University Nijmegen Medical Centre, Nijmegen, Netherlands | [6]Hospital Militaire Tunis, Tunis, Tunisia | [7]Centre for Dermatology Research, University of Manchester, Manchester, UK | [8]Department of Dermatology, King's College Hospital, King's College London, London, UK | [9]Skin and Laser Center of NJ, Ramsey, New Jersey, USA | [10]Department of Dermatology, Icahn School of Medicine at Mount Sinai, New York, New York, USA | [11]Redfern Strategic Medical Communications Inc, Springtown, Texas, USA | [12]Department of Dermatology, Perelman School of Medicine, University of Pennsylvania, Philadelphia, Pennsylvania, USA | [13]Department of Biostatistics, Epidemiology and Informatics, Perelman School Medicine School of Medicine, University of Pennsylvania, Philadelphia, Pennsylvania, USA | [14]Department of Dermatology, Apollo Hospitals, Chennai, India | [15]Department of Dermatology, Ain Shams University, Cairo, Egypt

Correspondence: Maria-Angeliki Gkini (maria-angeliki.gkini@nhs.net)

Received: 13 November 2024 | **Revised:** 11 December 2024 | **Accepted:** 25 December 2024

Funding: The authors received no specific funding for this work.

Keywords: disparities | epidemiology | ethnicity | genetics | psoriasis | quality of life | race | skin of color | treatment

ABSTRACT

Variations in epidemiology, pathophysiology, genetics, clinical presentation, management, quality of life (QoL) impact, and access to care and research exist globally across the spectrum of individuals with psoriasis. This article aims to provide an evidence-based update on the characteristics of psoriasis in individuals with skin of color (SOC), a population in which psoriasis data have historically been limited. A literature search was conducted from January 2018 until August 2023 in Pubmed/MEDLINE/Cochrane Library and identified studies with I-III level of evidence using Oxford Centre for Evidence-Based Medicine recommendations. Multiple factors (including biological and non-biological) contribute to differences in clinical features and therapeutic nuances in patient populations with SOC. The prevalence of plaque psoriasis is lower in people with SOC but tends to be more severe. People with SOC are less likely to receive biologic treatment. Although the QoL impact of psoriasis is worse in populations with SOC than in White populations, more research is needed to elucidate variations in presentation and impact across diverse populations. An important limitation of this study is that ethnicity, race, and SOC have not been defined universally or used consistently in the literature. Available evidence provides limited information on populations with SOC outside North America, which limits generalizability across global populations. Furthering our understanding of psoriasis in individuals with SOC is crucial to improving patient care outcomes for diverse patient populations worldwide.

Maria-Angeliki Gkini and Mio Nakamura contributed equally as first authors.

International Journal of Dermatology, 2025; 0:1–11
https://doi.org/10.1111/ijd.17651

1 | Introduction

Most psoriasis research and education focus on White populations and those with lighter skin, primarily of European descent in Europe and North America, whilst a paucity of data and clinical images of psoriasis exist among individuals with skin of color (SOC). Indeed, 8 of 10 countries globally lack basic epidemiologic data on psoriasis, according to a systematic analysis by the Global Psoriasis Atlas (GPA), and this impacts the provision of resources to attenuate the death, infirmity, and morbidity of this disorder [1].

A comprehensive 2018 review highlighted notable racial and ethnic differences in the presentation and treatment of psoriasis. For example, non-White individuals with psoriasis had a lesser prevalence but greater disease severity and a larger adverse impact on quality of life (QoL) compared with White populations in the United States (US) [2]. It is important to note, however, that many US prevalence estimates are based on population-based surveys of whether a healthcare provider has diagnosed an individual with psoriasis. Clinic-based or other limited population studies also have limitations with respect to estimates of prevalence.

In this paper, the term SOC refers to a diverse population of individuals of racial and ethnic backgrounds, including those who identify as Black or African, Hispanic or Latinx, Asian or Pacific Islander, American Indian or Native Alaskan, Indigenous Australian, Middle Eastern, biracial or multiracial, and non-White [3].

The International Psoriasis Council (IPC, https://psoriasiscouncil.org) convened a SOC Working Group to raise awareness of the diagnosis and treatment of psoriasis in all people. Members of the IPC developed the present article encapsulating recent literature regarding psoriasis in patients with SOC, particularly concerning epidemiology, pathophysiology, genetics, clinical presentation, management, QoL impact, and access to care and research.

2 | Materials and Methods

A systematic literature search was performed in 2023 by two independent researchers (MAG and MN) using databases and search terms shown in Figure 1. The robustness of the evidence of each study was evaluated according to the recommendations of the Oxford Centre for Evidence-Based Medicine [4]. Since health estimates for multiple populations were reported and results from multiple studies were assessed, for best reporting practice, The Guidelines for Accurate and Transparent Health Estimates Reporting (GATHER) [5] and The Consolidated Standards of Reporting Trials (CONSORT) [6] were followed.

3 | Results

3.1 | Epidemiology

The prevalence of psoriasis is increasing worldwide, regardless of race/ethnicity and geographic location [1]. However, limitations to population-based surveys and clinic surveys must be considered. White individuals are twice as likely to have psoriasis than non-White individuals [7–9]. In the US, the prevalence of psoriasis is 3.6% in White individuals [8]. In non-White populations in the US, the prevalence is 2.5% in Asian, 1.9% in Hispanic, 1.5% in Black, and 3.1% multiracial/other individuals [8].

The lower prevalence of psoriasis among certain subgroups of individuals with SOC may be due to decreased access to care and higher rates of undiagnosed disease in non-White populations, but most likely is due to genetic factors [10–12]. Epidemiological studies in other parts of the world beyond the US are limited, particularly in Latin America and the Caribbean regions [1]. The prevalence of generalized pustular psoriasis and erythrodermic psoriasis is higher in populations with SOC, predominantly Asian and Hispanic individuals compared with White individuals, while the prevalence of inverse psoriasis is lower in Asian and African populations [13, 14]. Black pediatric patients have a 6-fold increased odds of having palmoplantar psoriasis compared to White patients, and nail psoriasis was more common in Black and Hispanic/Latino pediatric patients compared with White patients (53.2%, 50.0%, and 33.9%, respectively) [15].

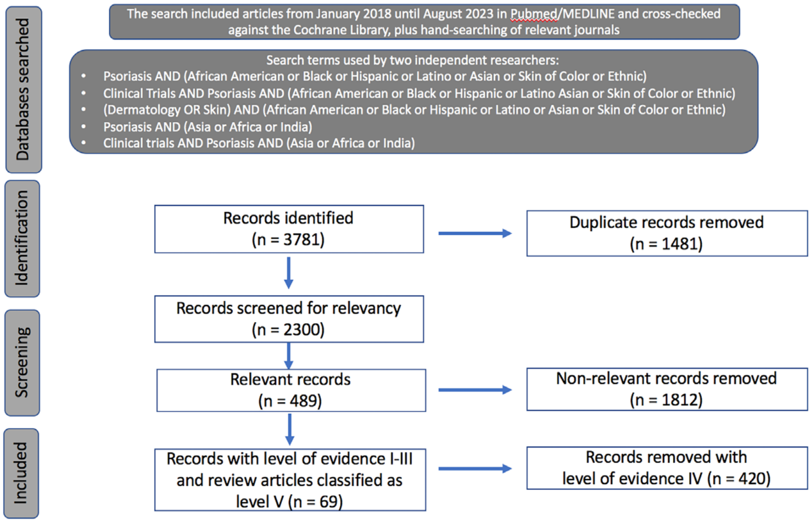

FIGURE 1 | PRISMA diagram showing databases, search terms, and number of articles identified and included in this review.

The mechanisms underlying racial and ethnic differences in the prevalence, severity, and presentation of psoriasis are not well delineated. Recent studies suggest that intrinsic differences in the gene expression related to the skin may underpin such differences. *HLA-Cw6* is the most significant risk allele for early-onset psoriasis in Europeans but not Han Chinese and Japanese. *HLA-Cw6* positivity in patients with psoriasis is generally higher in White individuals (European, Brazilian, and American ancestry) than in Asian people from various regions of Asia [16].

Klopot et al. found significant differences in global gene expression linked to inflammation in keratinocytes growing in 3D human skin equivalent (HSE) cultures made from individuals who self-reported as African American or White non-Hispanic [17]. This suggests that intrinsic proinflammatory circuits in African American keratinocytes and skin may account for disease disparities [17]. Few small genome-wide association studies have focused on African ancestry. This lack of diversity in genetic research for psoriasis in all populations, including populations with SOC, needs to be addressed in future studies [18].

3.2 | Clinical Presentation

Notably, often underrecognized differences in the presentation of psoriasis occur across diverse groups with SOC (Table 1) [19, 20]. Erythema on darker skin manifests as purple or lilac (or more often gray) versus red or pink in lighter skin tones (Figure 2). However, less marked violaceous or hyperpigmented lesions are seen in lighter skin. In the US, racial and ethnic minoritized populations are more likely to have undiagnosed psoriasis and less likely to see a dermatologist compared to White patients, according to Shao et al. [13]. Erroneous diagnoses (e.g., tinea versicolor) may contribute to the under-diagnosis of psoriasis in low- and middle-income countries. Indeed, people with dark skin tones are more likely to present with more violaceous or hyperpigmented plaques.

Heterogeneity exists even within populations with SOC, including those from the same self-identified or socially defined racial or ethnic background. Asian, Hispanic, and Black individuals are more likely than White individuals to present with more severe psoriasis and report greater impact on QoL, independent of psoriasis severity [13, 21–23].

With limited studies of relatively small sample sizes of non-White populations, it was shown that the average body surface area (BSA) of psoriasis in White adults is lower (1%–2%) compared to Black adults (3%–10%) [24]. Similarly, Latino patients were reported to have a greater BSA affected, particularly for the upper limbs, compared with White patients and had more severe psoriasis according to Investigator Global Assessment (IGA) scores [25]. However, the Psoriasis Area and Severity Index (PASI) did not mirror this. Ultimately, additional research is needed in this area.

While White patients and patients with SOC typically have similar clinical presentations of nail disease, patients with SOC are usually diagnosed nearly 3 years later and present with more severe nail disease [higher Nail Psoriasis Severity Index (NAPSI)] [26, 27]. Since psoriasis patients with SOC frequently have longitudinal melanonychia and a darker nail bed, onycholysis and pitting are less apparent. Furthermore, the lack of images depicting nail psoriasis in diverse skin types might contribute to delayed diagnosis [28].

3.3 | Treatment Options in Populations With SOC

According to Takeshita et al., in the US Medicare population, the likelihood of receiving biologics was 69% lower in Black patients compared with White patients [29]. These data were confirmed in a small US study; the likelihood of black patients and other races/ethnicities to receive biologic therapies to treat psoriasis was found to be significantly less compared with White patients [30]. The utilization of non-biologic systemic agents in Black patients was numerically higher compared with White patients (74.6% vs. 69.2%) [30]. However, the use of topical and non-biologic systemic therapies was significantly more frequent in Black vs. White patients (80.4% vs. 65.2%). Similarly, a significantly lower rate of biologic use was seen in patients in the other race categories compared with White patients (46.2% vs. 62.2%) [30].

A US study reviewing medical records showed that Black patients with psoriasis were less likely to receive cyclosporine and etanercept compared with White patients [31]. Other studies have shown that Black patients in the US and Canada are more likely treated with combination therapy, non-biologic systemic therapy, and topical therapy than non-Black patients [30, 32]. It should be noted that in these actual practice studies, some patients had already initiated a biologic at the time of enrolment. Latino patients with psoriasis in the US more often receive biologics than non-Latino patients [32].

A qualitative, free-listing study compared the responses of Black and White patients with psoriasis in terms of their word

TABLE 1 | Key features of psoriasis in skin of color.

- Black patients with psoriasis typically have thicker plaques with scales that look grayish and more purple compared with White individuals.
- Patients with SOC often have lasting dyspigmentation, which can be their primary complaint.
- Scalp psoriasis is more common in Asian and Black individuals versus Western European individuals. In Black females, it can be particularly severe.
- Asian and Hispanic individuals with psoriasis more often report stress as an exacerbating factor vs. White individuals.
- Medications (topical/systemic corticosteroids, beta-blockers/other anti-hypertensives, and antibiotics/antifungals) are more often reported as exacerbating factors in Asian patients compared with White patients.

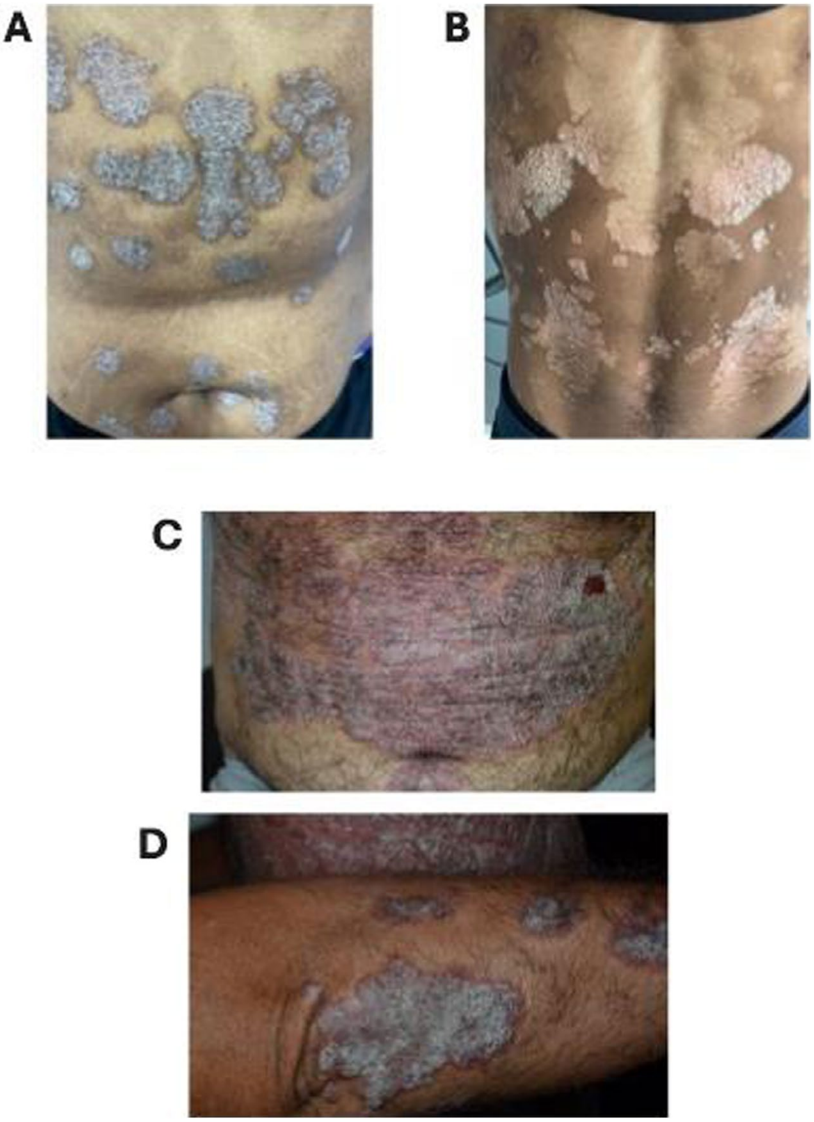

FIGURE 2 | Different clinical presentations of psoriasis in skin of color. Psoriasis lesions are characterized by a purple or lilac (more often gray on darker skin) hue (A–D), thick plaques (D), and extensive scaling with hyper- and hypopigmentation (C). Images courtesy of Mahira El Sayed, Ain Shams University, Cairo, Egypt, and Nejib Doss, Hospital Militaire Tunis, Tunis, Tunisia.

association with five psoriasis therapies (methotrexate, apremilast, infliximab, phototherapy, and self-injectable biologics) [33]. The study showed that Black patients who had never received biologics generally associated words such as “apprehension”, “side effects”, “immune suppression”, “unfamiliar,” and “dislike needles” with biologic agents. This finding provides insight into the potential causes of biologic treatment disparity observed between Black and White patients [33].

3.4 | Effect of Therapies in Populations With SOC

To date, no studies have delineated skin tone from race, ethnicity, and/or ancestry. Therefore, biological characteristics and social constructs should not be conflated with race, ethnicity, or ancestry, and conclusions should be cautiously drawn. A diverse clinical trial population is necessary to ensure the generalizability of trial results, but it is not appropriate to compare biological responses by race/ethnicity in most instances.

A number of studies have evaluated topical therapies in psoriasis patients with SOC (Table 2) [34–38]. As noted in a 2023 review by Schachner et al., racial/ethnic differences in skin barrier characteristics (e.g., ceramide levels, filaggrin null mutations, trans-epidermal water loss, and sensitivity) exist among patients with psoriasis, and these differences have implications for treatment [39]. Recommending the use of adjunctive skin care products (e.g., cleansers and moisturizers) may help improve symptoms and satisfaction with treatment in psoriasis patients with SOC [40].

With respect to the use of biologic agents, some studies have evaluated their effects on individuals with SOC and psoriasis (Table 3) [41–59]. So far, no meaningful differences in response to biologic treatments and safety were reported in psoriasis patients with SOC vs. White patients with psoriasis, with some exceptions. Patients with psoriasis and SOC in these studies covered a wide range of races and ethnicities, including Black, Latino, Indian, Egyptian, Lebanese, Malaysian, Philippino,

TABLE 2 | Summary of recent studies evaluating topical agents in SOC patients with psoriasis.

Study	Study type	Study population	Study groups	Results
Kontzias et al. 2023 [38]	Phase 3 post hoc	SOC, Fitzpatrick skin types IV to VI	CAL/BDP cream vs. CAL/BDP topical solution	• Results support the efficacy and safety of CAL/BDP cream in patients with SOC. • The greater convenience, formula acceptability, and overall satisfaction of CAL/BDP cream in SOC may improve adherence and treatment outcomes
Liu et al. 2023 [35]	Randomized, double-blind	SOC	Cal/BD foam vs. vehicle	• Cal/BD foam was well tolerated in patients with plaque psoriasis and SOC • Clear/almost clear IGA status occurred in 21% of Cal/BD foam patients vs. 0% of vehicle patients ($p=0.54$)
Desai et al. 2021 [34]	Phase 3 post hoc analysis	Hispanics	Halobetasol lotion vs. vehicle	• In Hispanics with moderate-to-severe psoriasis, disease severity was significantly reduced with once-daily HP 0.01% lotion and was well tolerated over 8 weeks
Alexis et al. 2021 [36]	Phase 3 post hoc analysis	Non-White and White, including Hispanics/Latinos	HP/TAZ lotion vs. vehicle	• In non-White, White, and Hispanic/Latino participants with psoriasis, HP/TAZ decreased the severity of the disease and was well tolerated over 8 weeks
Liu et al. 2020 [37]	Phase 4	Chinese patients	Calcipotriol + betamethasone Scalp solution vs. calcipotriol scalp solution	• Calcipotriol+betamethasone demonstrated efficacy and good tolerability in treating scalp psoriasis in Chinese patients • A two-compound gel (vs. calcipotriol scalp solution) resulted in more subjects with 100% treatment success (15.2% vs. 6.3%) at visits and fewer subjects with 0% treatment success (23.7% vs. 30.8%)

Abbreviations: Cal/BD, calcipotriene/betamethasone dipropionate; HP, halobetasol propionate; HP/TAZ, halobetasol propionate and tazarotene lotion; IGA, Investigator Global Assessment; SOC, skin of color.

Saudi Arabian, Singaporean, South Korean, Taiwanese, United Arab Emirates, Vietnamese, Korean, Japanese, and Chinese. Though not statistically different due to the small sample size, some studies suggest differences among groups of individuals with SOC. It should be noted, however, that there were baseline differences in disease severity among the groups that were not accounted for in the analyses.

Adsit et al. conducted a pooled analysis of four phase 3 clinical trials and showed that the efficacy of secukinumab in Hispanic patients might have been greater compared with non-Hispanics [59]. In a recent systematic review, ixekizumab tended to have the highest score of “clear/almost clear”, with values of 90.7% and 89.4%, and PASI 75 (defined as a 75% reduction from baseline PASI) with values of 98.8% and 96.6% for Asian and Latino patients, respectively. On the other hand, the highest score (86.8%) for “clear/almost clear” occurred for guselkumab in White psoriasis patients, while the highest score (75.0%) for “clear/almost clear” and PASI 75 score (91.7%) occurred in Black patients in response to brodalumab. However, the lack of details on ancestry and the lack of patients with SOC in the reviewed trials contributed to a key limitation of this review [43].

3.5 | Quality of Life

A general lack of studies on QoL exists in individuals with SOC and psoriasis. For example, while the Latino population is thought to have a greater severity of psoriasis, no studies have examined the disease burden in this group specifically [21]. The appearance of psoriasis plaques and post-inflammatory pigmentary changes in patients with SOC may lead to a greater negative impact on QoL [40, 60]. Other possible factors include cultural, socioeconomic, and educational factors [2]. The presence of psoriatic arthritis and nail psoriasis in patients with SOC also adds to decreased QoL [2].

There is a need for QoL measurements that are more culturally appropriate for populations with SOC [2, 61]. Results from the Psoriasis Longitudinal Assessment and Registry (PSOLAR), a prospective, international, disease-based registry, highlighted the need to consider measuring the QoL burden in each patient to enhance the care and clinical outcomes of patients and tailor management strategies independent of objective severity [23]. Scalp psoriasis, in particular, has a significant negative impact on QoL, is often challenging to treat, and is more common and

TABLE 3 | Recent studies evaluating racial/ethnic variations in biologic agents for psoriasis.

Study	Study type	Study population	Study groups	Efficacy results
Yu et al. 2023 [41]	Real-world (CorEvitas Psoriasis Registry)	Asian and Non-Hispanic White	Biologic therapy (TNFi, IL-17i, IL-23i or IL-12/23i)	• Improvements in disease activity and PROs at 6 months were similar in Asian and White patients, but skin-related QoL improvements were less in Asian patients
Honma et al. 2023 [42]	Open-label ProLOGUE study	Japanese	Brodalumab	• Itching and skin pain improved with brodalumab treatment in Japanese patients with psoriasis
Ferguson et al. 2023 [43]	Systematic review	Asia, White, Black, and Latino	Ixekizumab, guselkumab, brodalumab	• The efficacy of biologics to improve disease severity varied among different races and ethnicities
Jo et al. 2023 [44]	VOYAGE 1 and 2 post hoc analysis	Asian subpopulations	Guselkumab, placebo, or adalimumab	• At Week 24, complete clearance of scalp, hands, and/or feet was greater in guselkumab-treated patients vs. adalimumab-treated patients
Yamanaka et al. 2023 [45]	Phase 3 IMMspire study	Japanese	Risankizumab	• Risankizumab resulted in all patients achieving a GPP or EP response at week 16 with durable efficacy up to 180 weeks and was well tolerated
Enos et al. 2022 [46]	CorEvitas Psoriasis Registry	White (non-Hispanic), Black (non-Hispanic), Asian, Hispanic, or Other	Biologic therapy (TNFi, IL-17i, IL-23i or IL-12/23i)	• All racial/ethnic groups achieved similar PASI75, PASI90, and IGA 0/1 responses at 6 months
Foley et al. 2022 [47]	Real-world results from the REALIA study	Asia-Pacific and Middle East Regions	Conventional systemics (e.g., methotrexate), secukinumab vs. biologics (TNFαi, IL-12/23i, or IL-17Ai)	• Secukinumab vs. conventional systemics resulted in a greater percentage of chronic plaque psoriasis patients achieving "almost clear to clear skin" at Month 3 (64.7% vs. 22.8%) and Month 6 (61.8% vs. 20.8%) and was well tolerated
Youn et al. 2022 [48]	Phase3 VOYAGE 1/2 trials post hoc	Korean subpopulation	Guselkumab vs. adalimumab vs. placebo	• Guselkumab vs. adalimumab resulted in more patients achieving PASI 75 (93.7% vs. 66.7%) and IGA 0 (52.4% vs. 21.2%) responses at Week 24 • Guselkumab and adalimumab exhibited similar safety profiles • Results were similar to the overall VOYAGE 1 and 2 study population
Puig et al. 2021 [49]	Voyage 1 and 2	Hispanic and non-Hispanic	Guselkumab vs. adalimumab vs. placebo	• Guselkumab treatment in Hispanic and non-Hispanic populations exhibited similar safety and efficacy responses
Zhang et al. 2021 [50]	Systematic Review and Meta-Analysis	White and Asian	IL-17is	• Caucasians and Asians exhibited a similar short-term efficacy response (PASI 75 at Week 12) with IL-17 inhibitors

(Continues)

TABLE 3 | (Continued)

Study	Study type	Study population	Study groups	Efficacy results
Igarashi 2021 [51]	Phase 3 study (reSURFACE 1)	Japanese	Tildrakizumab vs. placebo	• Durable efficacy occurred with tildrakizumab treatment in Japanese patients with moderate to severe plaque psoriasis • More than 80% of patients achieved PASI 75 or PASI 90 at Week 28, and the response was maintained at Week 64
Okubo et al. 2021 [52]	Phase I population PK and exposure response	Japanese and non-Japanese (predominantly Caucasian)	Apremilast	• PKs and efficacy were similar between the Japanese and Caucasian subgroups • Apremilast had PASI 75, PASI 50, and sPGA responses similar to that in Caucasian subjects
Suleiman et al. 2020 [53]	Exposure–response relationship	Japanese and non-Japanese	Risankizumab	• Risankizumab 150 mg maximized PASI 90 and sPGA 0/1 response (77% and 88%), respectively • Exposure-safety results revealed no apparent relationship between risankizumab Cavg and safety variables
McMichael et al. 2019 [54]	Pooled AMAGINE-2/−3 randomized trials	Black, Asian, or white vs. Hispanic/Latino	Brodalumab	• Brodalumab was well tolerated and skin clearance response rates at Week 12 and Week 52 were similar across diverse racial and ethnic subgroups
Lee et al. 2019 [55]	CLEAR study subgroup	Asian	Secukinumab vs. ustekinumab	• Secukinumab treatment vs. ustekinumab resulted in a greater number of patients with improved PASI 90 at Week 16 (78.3% vs. 35.9) and at Week 52 (60.9% vs. 33.3%) and a faster response time (50% improvement in PASI at 2.8 weeks vs. versus 6.3 weeks) • No new or unexpected safety concerns were observed
Bhat et al. 2017 [56]	Phase 3 FIXTURE subgroup	Indian subpopulation	Secukinumab vs. etanercept vs. placebo	• More patients receiving secukinumab were PASI 90 responders at Week 12 vs. etanercept or placebo • Secukinumab was well tolerated, with no differences in AEs among groups
Wu et al. 2017 [57]	Phase III ERASURE subgroup	Taiwanese	Secukinumab vs. placebo	• More patients receiving secukinumab achieved PASI-75 at Week 12 vs. placebo • The efficacy and safety of secukinumab in Taiwanese patients were comparable with the overall global phase III population
Zhang et al. 2017 [58]	Phase 3	Mainland China, Taiwan, and Korea	Tofacitinib efficacy and safety vs. placebo	• A greater proportion of patients receiving tofacitinib achieved PGA and PASI 75 responses compared with placebo with no unexpected AEs
Adsit et al. 2017 [59]	Four Phase 3 trials	Hispanic vs. non-Hispanic	Secukinumab vs. etanercept	• PASI 75/90/100 and IGA 0/1 responses to secukinumab were greater than those to etanercept in both Hispanic and non-Hispanic patients

Abbreviations: AE, adverse event; Cavg, average plasma concentrations; EP, erythrodermic psoriasis; GPP, generalized pustular psoriasis; IGA, Investigator Global Assessment; IL-12/23i, interleukin-12/23 inhibitor; IL-17i, interleukin-17 inhibitor; IL-23i, interleukin-23 inhibitor; PASI, Psoriasis Area and Severity Index; PK, pharmacokinetic; PRO, patient-reported outcome; QoL, quality of life; sPGA, static Physician Global Assessment; TNFi, tumor necrosis factor inhibitor.

severe in Asian and Black patients (particularly Black females) compared to White patients [24, 62].

3.6 | Access to Care and Clinical Research

Healthcare access is influenced by age, socioeconomic status, health literacy, disabilities, location of residence (e.g., urban, suburban, or rural), and other factors [10]. Access to advanced treatments like biologics is restricted in many developing countries due to a lack of government or insurance support. As a result, patients with SOC may be disproportionately affected.

Patients with psoriasis and SOC experience a longer time to diagnose and present with more severe disease, possibly due to decreased access to care [11, 27]. In the US, health insurance status, cost of care, health literacy, language accessibility, experiences of bias and discrimination leading to medical mistrust, and different cultural views of psoriasis, among many other factors that contribute to poor cultural mindfulness, may influence the ability to access and experience high-quality care among people with SOC. Hispanic and Black patients with psoriasis experience more provider-related bias, delayed diagnoses, misdiagnosis, and stereotyping compared with White patients [63]. These factors may contribute to the lack of trust, confidence, and fear that patients with psoriasis and SOC feel toward their healthcare providers.

Individuals with psoriasis and SOC have had limited representation in clinical trials [10], which are the least diverse among dermatologic conditions. From 2010 to 2015, there was significant under-representation of Black participants in clinical trials for new molecular therapies for psoriasis [64, 65]. Recent studies, including a placebo-controlled trial of guselkumab in individuals with psoriasis and SOC, have been designed to address that gap.

4 | Discussion

Multiple US surveys have shown that dermatologists believed that their training was lacking in diagnosing dermatoses in populations with SOC [66]. A contributing factor was the under-representation of descriptions of psoriasis in populations with SOC in dermatology textbooks and atlas images. A further challenge is the absence of universally agreed terms to describe patients of different ethnic and racial backgrounds. Most of the studies reviewed here relate to countries with abundant research resources, and more research is needed in underserved areas of the world in order to get an estimation of the global representation of psoriasis in populations with SOC.

The prevalence of psoriasis is increasing worldwide and continues to be highest in White populations [1]. However, among people with psoriasis, there appears to be a greater objective and subjective burden of disease among non-White populations. The under-diagnosis and treatment of psoriasis in individuals with SOC occurs for various reasons. Psoriasis lesions in patients with SOC differ from those in White populations with a less discernible or varied expression of color (more often gray) and more prominent and long-standing post-inflammatory hyperpigmentation [19, 20]. Education should comprise training on these characteristics related to SOC to avoid misdiagnosis or delay in diagnosis (see diagnostic recommendations from the Global Psoriasis Atlas) [67]. There may also be barriers to accessing care related to socioeconomic and cultural factors in populations with SOC [27]. This would also include the downstream effects of structural racism. Moreover, the lack of inclusion of populations with SOC in clinical trials and inadequate data reporting on race and ethnicity in research and publications contributes to the under-recognition of psoriasis in populations with SOC [62]. The VISIBLE study (NCT05272150) initiated in 2022 represents the first study dedicated to psoriasis in patients with SOC and is a call to action for more equitable research in psoriasis. Also, in certain populations of individuals with SOC, socioeconomic factors (e.g., insurance coverage), inadequate education regarding various treatments, and cultural or religious views of psoriasis and medical treatment may be barriers to adequate treatment [68]. Finally, some areas of the world with a large population with SOC, such as Africa, South America, and Southern Asia, do not have equitable access to the same biologics versus other regions with predominantly White populations.

Numerous studies of genetic polymorphisms and their effects on psoriasis risk in different racial/ethnic populations have been conducted (for a review, see Alexis et al.) [19]. However, robust studies of comparative and causal analyses and fine mapping of ancestral genes among diverse populations are needed to allow for precision medicine.

Several studies suggest a greater negative impact of psoriasis on QoL in psoriasis patients with SOC [23, 40, 60] and emphasize the need for socially and culturally sensitive standardized questionnaires to improve the assessment of QoL impact. People with SOC, in general, are not adequately represented in clinical trials, leading to limited data about the efficacy and safety of biologics or small molecules in this population [62]. *Post hoc* analyses from large-scale phase 3 and 4 studies have attempted to fill the gap regarding the lack of data in SOC patients, but these studies have limitations such as small sample size.

Important limitations of this review are severalfold. Firstly, the terms ethnicity, race, and SOC have not been defined universally or used consistently in the literature. Secondly, the available evidence provides limited information on populations with SOC outside North America, which limits generalizability across global populations. Thirdly, biological and genetic differences among different ancestral populations should not be assigned to race; such differences do not constitute health disparities.

Although the 2016 World Health Organization report focused on the need to fight stigma and reduce discrimination surrounding psoriasis [69], further steps remain so that patients with psoriasis globally can live their lives with dignity and access timely and appropriate treatment for their condition. The Global Psoriasis Atlas (https://www.globalpsoriasisatlas.org), a collaboration of the International Federation of Psoriasis Associations, International League of Dermatological Societies, and IPC, aims to help improve insights into the epidemiology of psoriasis and care of people with psoriasis and to highlight unmet needs.

5 | Conclusion

This literature review invokes an important call to action by the IPC. Education on diagnosing and treating psoriasis in all populations, including patients with SOC, must be prioritized. Creating optimal educational materials, including educational photo galleries of all skin tones, is vital to improving the early treatment of psoriasis worldwide. “Hot topic” discussions among experts are essential to developing internationally accepted nomenclature and definitions regarding what is designated as SOC, geographic ancestry, and race and to relate psoriasis to well-defined populations according to agreed definitions. Future research on psoriasis in people with SOC can be harmonized based on such standards.

Conflicts of Interest

The authors declare no conflicts of interest.

References

1. R. Parisi, I. Y. K. Iskandar, E. Kontopantelis, et al., “National, Regional, and Worldwide Epidemiology of Psoriasis: Systematic Analysis and Modelling Study,” *BMJ* 369 (2020): m1590.

2. B. P. Kaufman and A. F. Alexis, “Psoriasis in Skin of Color: Insights Into the Epidemiology, Clinical Presentation, Genetics, Quality-Of-Life Impact, and Treatment of Psoriasis in Non-White Racial/Ethnic Groups,” *American Journal of Clinical Dermatology* 19 (2018): 405–423.

3. J. B. Brown-Korsah, S. McKenzie, D. Omar, N. C. Syder, N. Elbuluk, and S. C. Taylor, “Variations in Genetics, Biology, and Phenotype of Cutaneous Disorders in Skin of Color - Part I: Genetic, Biologic, and Structural Differences in Skin of Color,” *Journal of the American Academy of Dermatology* 87 (2022): 1239–1258.

4. OCEBM Levels of Evidence Working Group, *The Oxford 2011 Levels of Evidence* (Oxford, UK: Oxford Centre for Evidence-Based Medicine, 2011), http://www.cebm.net/index.aspx?o=5653.

5. G. A. Stevens, L. Alkema, R. E. Black, et al., “Guidelines for Accurate and Transparent Health Estimates Reporting: The GATHER Statement,” *PLoS Medicine* 13 (2016): e1002056.

6. R. P. Merkow, A. H. Kaji, and K. M. F. Itani, “The CONSORT Framework,” *JAMA Surgery* 156 (2021): 877–878.

7. J. Liu, A. Thatiparthi, A. Martin, A. Egeberg, and J. J. Wu, “Prevalence of Psoriasis Among Adults in the US 2009-2010 and 2013-2014 National Health and Nutrition Examination Surveys,” *Journal of the American Academy of Dermatology* 84 (2021): 767–769.

8. A. W. Armstrong, M. D. Mehta, C. W. Schupp, G. C. Gondo, S. J. Bell, and C. E. M. Griffiths, “Psoriasis Prevalence in Adults in the United States,” *JAMA Dermatology* 157 (2021): 940–946.

9. J. Burshtein, A. Strunk, and A. Garg, “Incidence of Psoriasis Among Adults in the United States: A Sex- and Age-Adjusted Population Analysis,” *Journal of the American Academy of Dermatology* 84 (2021): 1023–1029.

10. J. Takeshita, J. Chau, K. C. Duffin, and N. Goel, “Promoting Diversity, Equity, and Inclusion for Psoriatic Diseases,” *Journal of Rheumatology* 49, no. 6 Suppl 1 (2022): 48–51.

11. A. H. Fischer, D. B. Shin, J. M. Gelfand, and J. Takeshita, “Health Care Utilization for Psoriasis in the United States Differs by Race: An Analysis of the 2001-2013 Medical Expenditure Panel Surveys,” *Journal of the American Academy of Dermatology* 78 (2018): 200–203.

12. S. K. Kurd and J. M. Gelfand, “The Prevalence of Previously Diagnosed and Undiagnosed Psoriasis in US Adults: Results From NHANES 2003-2004,” *Journal of the American Academy of Dermatology* 60 (2009): 218–224.

13. K. Shao, J. Hooper, and H. Feng, “Racial and Ethnic Health Disparities in Dermatology in the United States. Part 2: Disease-Specific Epidemiology, Characteristics, Management, and Outcomes,” *Journal of the American Academy of Dermatology* 87 (2022): 733–744.

14. D. Yan, L. Afifi, C. Jeon, K. M. Cordoro, and W. Liao, “A Cross-Sectional Study of the Distribution of Psoriasis Subtypes in Different Ethno-Racial Groups,” *Dermatology Online Journal* 24 (2018): 13030.

15. B. Roman, S. Collette, A. M. Smith, and A. Theos, “Black and Male Children Have an Increased Risk of Palmoplantar Psoriasis Compared to White Children,” *Pediatric Dermatology* 40 (2023): 1071–1073.

16. L. Chen and T. F. Tsai, “HLA-Cw6 and Psoriasis,” *British Journal of Dermatology* 178 (2018): 854–862.

17. A. Klopot, G. Baida, A. Kel, L. C. Tsoi, B. E. Perez White, and I. Budunova, “Transcriptome Analysis Reveals Intrinsic Proinflammatory Signaling in Healthy African American Skin,” *Journal of Investigative Dermatology* 142 (2022): 1360–1371.e15.

18. T. A. Jamerson, Q. Li, S. Sreeskandarajan, et al., “Roles Played by Stress-Induced Pathways in Driving Ethnic Heterogeneity for Inflammatory Skin Diseases,” *Frontiers in Immunology* 13 (2022): 845655.

19. A. F. Alexis and P. Blackcloud, “Psoriasis in Skin of Color: Epidemiology, Genetics, Clinical Presentation, and Treatment Nuances,” *Journal of Clinical and Aesthetic Dermatology* 7 (2014): 16–24.

20. S. A. Davis, S. Narahari, S. R. Feldman, W. Huang, R. O. Pichardo-Geisinger, and A. J. McMichael, “Top Dermatologic Conditions in Patients of Color: An Analysis of Nationally Representative Data,” *Journal of Drugs in Dermatology* 11 (2012): 466–473.

21. A. G. Ashbaugh, C. Ekelem, Y. Landaverde, and N. A. Mesinkovgska, “Psoriatic Disease in the US Latino Population: A Comprehensive Review,” *American Journal of Clinical Dermatology* 21 (2020): 265–274, https://doi.org/10.1007/s40257-019-00498-8.

22. S. Narla, C. R. Heath, A. Alexis, and J. I. Silverberg, “Racial Disparities in Dermatology,” *Archives of Dermatological Research* 315 (2023): 1215–1223.

23. J. Takeshita, M. Augustin, E. M. G. J. de Jong, et al., “Health-Related QOL Differs by Race/Ethnicity in North American Patients With Psoriasis: Results From PSOLAR,” *Journal of Investigative Dermatology* 142 (2022): 2528–2531.e3.

24. Y. Lytvyn, M. Sachdeva, A. Mufti, and J. Yeung, “Dermatology: How to Manage Psoriasis and Recognize Differences in Pathophysiology and Presentation in Patients With Skin of Colour,” *Drugs Context* 11 (2022): 1–12.

25. A. G. Ashbaugh, G. Brody, Y. Landaverde, C. Ekelem, and N. A. Mesinkovska, “A Cross-Sectional Study of Latino Patients Screened for Psoriasis Clinical Trials at the University of California-Irvine,” *Journal of the American Academy of Dermatology* 85 (2021): 1021–1023.

26. T. Bosworth, “Nail Psoriasis in Black Patients Often Overlooked,” https://www.mdedge.com/dermatology/article/266733/psoriasis/nail-psoriasis-black-patients-often-overlooked#:~:text=90%25%2C%20Dr.-,Lipner%20said.,Lipner.

27. M. J. Chang, D. Lee, A. D. Desai, and S. R. Lipner, “Disparities in Time to Diagnosis and Disease Severity in Skin of Colour Patients With Nail Psoriasis: A Retrospective Analysis,” *Journal of the European Academy of Dermatology and Venereology* 37 (2023), https://doi.org/10.1111/jdv.19110.

28. M. J. Chang, J. W. Ricardo, and S. R. Lipner, “Prioritization of Race and Ethnicity Reporting and Recruitment of Diverse Participants,” *International Journal of Dermatology* 62 (2023): e318–e319.

29. J. Takeshita, J. M. Gelfand, P. Li, et al., “Psoriasis in the US Medicare Population: Prevalence, Treatment, and Factors Associated With Biologic Use,” *Journal of Investigative Dermatology* 135 (2015): 2955–2963.

30. W. T. Hodges, T. Bhat, N. S. Raval, et al., “Biologics Utilization for Psoriasis Is Lower in Black Compared With White Patients,” *British Journal of Dermatology* 185 (2021): 207–209.

31. M. A. Bell, K. A. Whang, J. Thomas, C. Aguh, and S. G. Kwatra, “Racial and Ethnic Disparities in Access to Emerging and Frontline Therapies in Common Dermatological Conditions: A Cross-Sectional Study,” *Journal of the National Medical Association* 112 (2020): 650–653.

32. L. Bonomo, B. J. Abittan, P. W. Hashim, C. Karki, M. Mason, and M. Lebwohl, “Combination Use of Systemic Therapies in Psoriasis: Baseline Characteristics From the Corrona Psoriasis Registry,” *Journal of Drugs in Dermatology* 18 (2019): 731–740.

33. J. Takeshita, W. T. Eriksen, V. T. Raziano, et al., “Racial Differences in Perceptions of Psoriasis Therapies: Implications for Racial Disparities in Psoriasis Treatment,” *Journal of Investigative Dermatology* 139 (2019): 1672–1679.

34. S. R. Desai, B. Glick, J. Q. Del Rosso, S. Harris, and A. Jacobson, “Once-Daily Halobetasol Propionate 0.01% Lotion for Moderate-To-Severe Plaque Psoriasis: Phase 3 Analysis of Hispanic Participants,” *Journal of Drugs in Dermatology* 20 (2021): 252–258.

35. J. Liu, A. Cices, B. Kaufman, I. Sanabria-Gonzalez, and A. Alexis, “Efficacy and Safety of Calcipotriene/Betamethasone Dipropionate Foam in the Treatment of Psoriasis in Skin of Color,” *Journal of Drugs in Dermatology* 22 (2023): 165–173.

36. A. F. Alexis, S. R. Desai, G. Han, and A. Jacobson, “Fixed-Combination Halobetasol Propionate and Tazarotene Lotion for Psoriasis in Patients With Skin of Color,” *Journal of Drugs in Dermatology* 20 (2021): 744.

37. L. Liu, C. Zhang, J. Wang, et al., “Comparison of Safety and Efficacy Between Calcipotriol Plus Betamethasone Dipropionate Gel and Calcipotriol Scalp Solution as Long-Term Treatment for Scalp Psoriasis in Chinese Patients: A National, Multicentre, Prospective, Randomized, Active-Controlled Phase 4 Trial,” *European Journal of Dermatology* 30 (2020): 580–590.

38. C. L. Kontzias, A. Curcio, B. Gorodokin, et al., “Efficacy, Convenience, and Safety of Calcipotriene-Betamethasone Dipropionate Cream in Skin of Color Patients With Plaque Psoriasis,” *Journal of Drugs in Dermatology* 22 (2023): 668–672.

39. L. Schachner, A. Alexis, A. Andriessen, et al., “Supplement Individual Article: The Importance of a Healthy Skin Barrier From the Cradle to the Grave Using Ceramide-Containing Cleansers and Moisturizers: A Review and Consensus,” *Journal of Drugs in Dermatology* 22 (2023): SF344607s3–SF344607s14.

40. A. Lexis, H. Woolery-Lloyd, A. Andriessen, J. Koo, A. McMichael, and G. Han, “Evolving Concepts in Psoriasis: Special Considerations for Patients With Skin of Color, Skin Barrier Dysfunction, and the Role of Adjunctive Skin Care,” *Journal of Drugs in Dermatology* 21 (2022): 1054–1060.

41. C. Yu, G. Wang, R. T. Burge, et al., “Outcomes of Biologic Use in Asian Compared With Non-Hispanic White Adult Psoriasis Patients From the CorEvitas Psoriasis Registry,” *Dermatology and Therapy* 13 (2023): 187–206.

42. M. Honma, Y. Kanai, K. Murotani, et al., “Effectiveness of Brodalumab in Improving Itching and Skin Pain in Japanese Patients With Psoriasis: The ProLOGUE Study,” *Journal of Dermatology* 50 (2023): 453–461.

43. J. E. Ferguson, E. W. Seger, J. White, and A. McMichael, “Racial/Ethnic Differences in Treatment Efficacy and Safety for Moderate-To-Severe Plaque Psoriasis: A Systematic Review,” *Archives of Dermatological Research* 315 (2023): 41–50.

44. S. J. Jo, Y. H. Huang, T. F. Tsai, et al., “Efficacy of Guselkumab in Difficult-To-Treat Psoriasis Regions: Data From VOYAGE 1 and VOYAGE 2 Asian Subpopulations,” *Journal of Dermatology* 50 (2023): 1180–1189.

45. K. Yamanaka, Y. Okubo, I. Yasuda, N. Saito, I. Messina, and A. Morita, “Efficacy and Safety of Risankizumab in Japanese Patients With Generalized Pustular Psoriasis or Erythrodermic Psoriasis: Primary Analysis and 180-Week Follow-Up Results From the Phase 3, Multicenter IMMspire Study,” *Journal of Dermatology* 50 (2023): 195–202.

46. C. W. Enos, J. Z. Yi, R. R. McLean, et al., “Similar Response to Biologic Therapy Across Racial and Ethnic Groups Among Patients With Psoriasis Enrolled in the CorEvitas Psoriasis Registry,” *Journal of the American Academy of Dermatology* 87 (2022): 1087–1089.

47. P. Foley, T. F. Tsai, K. Rodins, et al., “Effectiveness and Safety of Secukinumab for Psoriasis in a Real-World Clinical Setting in the Asia-Pacific and Middle East Regions: Results From the REALIA Study,” *Dermatology and Therapy* 12 (2022): 511–527.

48. S. W. Youn, D. Y. Yu, T. Y. Kim, et al., “Efficacy and Safety of Guselkumab Compared With Placebo and Adalimumab in Korean Patients With Moderate-To-Severe Psoriasis: Post-Hoc Analysis From the Phase III, Double-Blind, Placebo- and Active-Comparator-Controlled VOYAGE 1/2 Trials,” *Journal of Dermatological Treatment* 33 (2022): 535–541.

49. L. Puig, J. J. Wu, M. J. Gooderham, et al., “Consistent Response to Guselkumab Treatment Between Hispanic and Non-Hispanic Patients With Psoriasis: An Analysis From VOYAGE 1 and VOYAGE 2,” *Journal of Dermatological Treatment* 32 (2021): 484–491.

50. D. Zhang, J. Qiu, X. Liao, et al., “Comparison of Efficacy of Anti-Interleukin-17 in the Treatment of Psoriasis Between Caucasians and Asians: A Systematic Review and Meta-Analysis,” *Front Med (Lausanne)* 8 (2021): 814938.

51. A. Igarashi, H. Nakagawa, A. Morita, et al., “Efficacy and Safety of Tildrakizumab in Japanese Patients With Moderate to Severe Plaque Psoriasis: Results From a 64-Week Phase 3 Study (reSURFACE 1),” *Journal of Dermatology* 48 (2021): 853–863.

52. Y. Okubo, M. Ohtsuki, M. Komine, et al., “Population Pharmacokinetic and Exposure-Response Analysis of Apremilast in Japanese Subjects With Moderate to Severe Psoriasis,” *Journal of Dermatology* 48 (2021): 1652–1664.

53. A. A. Suleiman, A. Khatri, R. K. Oberoi, and A. A. Othman, “Exposure-Response Relationships for the Efficacy and Safety of Risankizumab in Japanese Subjects With Psoriasis,” *Clinical Pharmacokinetics* 59 (2020): 575–589.

54. A. McMichael, S. R. Desai, A. Qureshi, S. Rastogi, and A. F. Alexis, “Efficacy and Safety of Brodalumab in Patients With Moderate-To-Severe Plaque Psoriasis and Skin of Color: Results From the Pooled AMAGINE-2/−3 Randomized Trials,” *American Journal of Clinical Dermatology* 20 (2019): 267–276.

55. M. G. Lee, Y. H. Huang, J. H. Lee, et al., “Secukinumab Demonstrates Superior Efficacy and a Faster Response in Clearing Skin in Asian Subjects With Moderate to Severe Plaque Psoriasis Compared With Ustekinumab: Subgroup Analysis From the CLEAR Study,” *Journal of Dermatology* 46 (2019): 752–758.

56. R. M. Bhat, B. Leelavathy, S. S. Aradhya, et al., “Secukinumab Efficacy and Safety in Indian Patients With Moderate-To-Severe Plaque Psoriasis: Sub-Analysis From FIXTURE, a Randomized, Placebo-Controlled, Phase 3 Study,” *Indian Dermatology Online Journal* 8 (2017): 16–24.

57. N. L. Wu, C. J. Hsu, F. J. Sun, and T. F. Tsai, “Efficacy and Safety of Secukinumab in Taiwanese Patients With Moderate to Severe Plaque Psoriasis: Subanalysis From ERASURE Phase III Study,” *Journal of Dermatology* 44 (2017): 1129–1137.

58. J. Zhang, T. F. Tsai, M. G. Lee, et al., “The Efficacy and Safety of Tofacitinib in Asian Patients With Moderate to Severe Chronic Plaque Psoriasis: A Phase 3, Randomized, Double-Blind, Placebo-Controlled Study,” *Journal of Dermatological Science* 88 (2017): 36–45.

59. S. Adsit, E. R. Zaldivar, H. Sofen, et al., “Secukinumab Is Efficacious and Safe in Hispanic Patients With Moderate-To-Severe Plaque Psoriasis: Pooled Analysis of Four Phase 3 Trials,” *Advances in Therapy* 34 (2017): 1327–1339.

60. Z. Kwan, Y. B. Bong, L. L. Tan, et al., “Socioeconomic and Sociocultural Determinants of Psychological Distress and Quality of Life Among Patients With Psoriasis in a Selected Multi-Ethnic Malaysian Population,” *Psychology, Health & Medicine* 22 (2017): 184–195.

61. Y. Zhao, S. P. Li, L. Liu, J. L. Zhang, and G. Chen, “Does the Choice of Tariff Matter?: A Comparison of EQ-5D-5L Utility Scores Using Chinese, UK, and Japanese Tariffs on Patients With Psoriasis Vulgaris in Central South China,” *Medicine (Baltimore)* 96 (2017): e7840.

62. G. Yadav, J. Yeung, Y. Miller-Monthrope, et al., “Unmet Need in People With Psoriasis and Skin of Color in Canada and the United States,” *Dermatology and Therapy* 12 (2022): 2401–2413.

63. S. G. Brown, 3rd, C. B. C. Cobb, and V. M. Harvey, “Racial and Ethnic Health Disparities in Dermatology,” *Dermatologic Clinics* 41 (2023): 325–333.

64. M. V. Ha and C. Wong, “Racial Representation in Clinical Trials for Dermatological New Molecular Entities,” *Clinical and Experimental Dermatology* 47 (2022): 386–388.

65. A. Sevagamoorthy, P. Sockler, C. Akoh, and J. Takeshita, “Racial and Ethnic Diversity of US Participants in Clinical Trials for Acne, Atopic Dermatitis, and Psoriasis: A Comprehensive Review,” *Journal of Dermatological Treatment* 33 (2022): 3086–3097.

66. A. Barve, M. Shah, and P. Sheth, “Skin of Color Images in Pediatric Dermatology Textbooks,” *Pediatric Dermatology* 38, no. Suppl 2 (2021): 144–145.

67. M. Abo-Tabik, R. Parisi, S. C. Willis, et al., “Development of Clinical Diagnostic Criteria for Chronic Plaque Psoriasis: An International e-Delphi Study,” *British Journal of Dermatology* 185 (2021): 455–456.

68. E. Akuffo-Addo, T. Udounwa, J. Chan, and L. Cauchi, “Exploring Biologic Treatment Hesitancy Among Black and Indigenous Populations in Canada: A Review,” *Journal of Racial and Ethnic Health Disparities* 10 (2023): 942–951.

69. WHO Report on Psoriasis, 2016, https://iris.who.int/bitstream/handle/10665/204417/9789241565189_eng.pdf?sequence=1.