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A large-scale retrospective study in China explores risk factors for disease severity in plaque psoriasis

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Severe psoriasis has a long course and poor outcome, and it has long been a problem for patients. Understanding the independent risk factors that contribute to patients with severe psoriasis is critical for the development of effective treatment strategies. This large, multicenter study recruited 2,109 plaque psoriasis patients from 12 hospitals across China (October 31, 2019 – May 31, 2022). The logistic regression model underwent internal validation and external validation using two independent cohorts over future time periods (June 1, 2022 – January 31, 2023). The discriminative power of our model was substantiated by a C-index of 0.863 (95% CI: 0.848–0.879) in internal validation, further affirmed through 1,000 bootstrap validation (C-index: 0.860, 95% CI: 0.836–0.885) and external validation cohorts, where the C-index reached up to 0.910 (95% CI: 0.868–0.953) and 0.951 (95% CI: 0.924–0.977) in 2 external validation cohorts. To enhance accessibility for clinicians, the model has been made available as a dynamic nomogram and QR code. Our study identified 10 risk factors (the "DELPHI" consensus dichotomy, the DLQI index, the extent of skin involvement as measured by body surface area, the age of the patient at the time of clinical visit, sex, body weight in kilograms, career, the presence of scalp involvement, facial involvement, and arthropathy) for the overall severity of psoriasis (PASI ≥ 10). "Nomogram-10" provides clinicians with a practical tool to develop personalized intervention strategies based on an individual's risk profile.

***Trial registration*: Chinese Clinical Trial Registry: ChiCTR1900024852.**

Keywords Plaque psoriasis, Severity risk, Nomogram, Risk assessment, Logistic regression, Severe psoriasis

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Plaque psoriasis (PP) is an inflammatory, immune-mediated dermatological disorder, marked by raised, scaly patches on the skin, impacting around 2–3% of the global population[1–4]. Psoriasis presents in four main types: psoriasis vulgaris, pustular psoriasis, psoriatic arthritis, and erythrodermic psoriasis. PP, being the most common form, may progress into more severe subtypes if not timely diagnosed or treated[1,2,5]. Developments in biologics and tailored treatment strategies have incrementally enhanced the therapeutic results for psoriasis patients[2,4,5]. Nonetheless, treatment outcomes for severe psoriasis continue to be less than ideal, presenting challenges for numerous clinicians. The overall severity of psoriasis is typically assessed using the "rule of tens" classification, which categorizes patients as having severe or moderate-to-severe psoriasis when their psoriasis area and severity index (PASI) score is ≥ 10, body surface area (BSA) $\geq 10\%$, or Dermatology Life Quality Index (DLQI) is ≥ 10[6–13]. The effectiveness of treatment for these patients depends on the clinician's evaluation of the type and severity of psoriasis[5–7]. The identification of independent risk factors for severe psoriasis is crucial in improving clinical outcomes for these patients[5–13]. A clinical prediction model, whether parametric, semiparametric, or nonparametric, is a mathematical model that estimates the likelihood of an individual developing a disease or its progression[14]. Accurately predicting the severity risk for individual psoriasis patients remains a crucial yet unmet need in clinical dermatology.

Understanding the independent risk factors that contribute to severe psoriasis in patients is critical for the development of effective treatment strategies. Our study aimed to identify independent risk factors for severe psoriasis (PASI ≥ 10). In this study, we used logistic regression methods to systematically investigate and identify the independent clinical factors that significantly affect the severity of patients' conditions in the target population. The findings are expected to guide personalized treatment plans, improve patient outcomes, and ultimately enhance their quality of life.

Methods

Study population

In this study, we undertook an extensive, multicenter retrospective analysis of 3,692 plaque psoriasis patients screened from 12 hospitals across China, all of whom were diagnosed with plaque psoriasis (ICD-10-CM: L40.0). The exclusion criterion were patients with incomplete data, a history of confounding skin conditions. Ultimately, 2,109 cases were included in the analysis, spanning from October 31, 2019 to May 31, 2022. The external validation cohort was derived from 198 patients recruited from the University of Hong Kong-Shenzhen Hospital and Peking Union Medical College Hospital (116 + 82 patients) and the Xinjiang Uygur Autonomous Region People's Hospital (193 patients) between June 1, 2022, and January 31, 2023 (Fig. 1).

Data were sourced from a comprehensive multicenter database created by the Psoriasis Biologics Treatment Collaborative Group of the Dermatologists Branch of the Chinese Medical Doctors' Association. This database includes detailed clinical characteristics of plaque psoriasis patients from multiple centers across China. However, for several reasons, the data is currently not open to the public and cannot be accessed externally. The trial was registered with the WHO International Clinical Trials Registry Platform Level 1 Registry (China Clinical Trials Registry, https://www.chictr.org.cn/index.html) under registration number ChiCTR1900024852.

The clinical characteristics of the patients included in this study were derived from the initial diagnostic information sourced from a comprehensive, multicenter database of plaque psoriasis patients in China. Our study

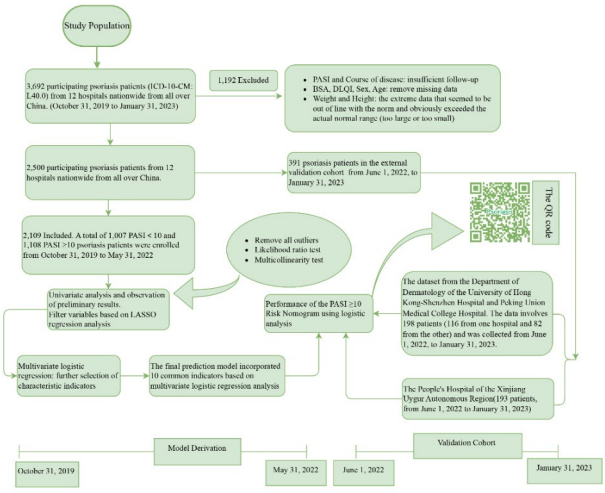

Fig. 1. "Study flow: formation of the derivation, internal validation, and external validation cohorts of patients hospitalized with psoriasis." Figure legend: Please scan the QR code in the flowchart with your smartphone with an internet connection. Please wait for 5–15 s. A web version of the prediction model will load on your browser.

adhered to the guidelines outlined in the *Transparent Reporting of a Multivariable Prediction Model for Individual Prognosis or Diagnosis statement* for transparent reporting of multivariable prediction model development and validation[12,15]. All methods were performed in accordance with the relevant guidelines and regulations, and in compliance with the Declaration of Helsinki. The study was approved by the Ethics Committee of The University of Hong Kong-Shenzhen Hospital ([2019] 181), and informed consent was obtained from all participants and/or their legal guardians.

For this study, we pulled information on patients registered in the database from October 31, 2019, to May 31, 2022. The index date for each patient was defined as the date of their initial registration in the database. Rather than being collected at the time of the first diagnosis of psoriasis, patient demographic and disease characteristics began to be collected at the time of first inclusion in the database. This ensures that the data reflect the patient's condition and treatment status at the start of their participation in the study. Psoriasis severity was assessed using the PASI, BSA, and DLQI. Severe or moderate-to-severe psoriasis was defined based on the following criteria: PASI $\geq$ 10, BSA $\geq$ 10%, or DLQI $\geq$ 10. Data from some patients with PASI $\geq$ 10, BSA $\geq$ 10%, and DLQI $\geq$ 10 were mostly consistent, but sometimes inconsistent. Because of the common use of the PASI to assess the condition and for the sake of harmonization, we only used PASI $\geq$ 10 as the outcome measure.

All patient data are shown in Table 1. Researchers with systematic training evaluated the patients' skin lesions. The variables included in the prediction model are defined as follows: Demographic Variables: age at visit, sex, height (m), weight (kg), body mass index (BMI), smoking history, drinking history, marital status, education level (categorized as elementary school, middle school, secondary students, junior college, undergraduate, and master's degree or above), occupational classification, employment status. The education levels were categorized into elementary school, middle school, high school, secondary students, junior college, undergraduate, and master's degree or above. Occupations were categorized into company employee, retired, conventional agriculture, student, teacher, industry and trade, information technology industry, doctor/nurse, and others. Upon statistical analysis, we observed no significant differences among the detailed subcategories. Given this lack of variability, we merged the subcategories to simplify our analysis: education level: bachelor's degree or below, master's degree or above. occupation: student, others.

Disease Characteristics: Duration of psoriasis: the length of time the patient has had psoriasis. BSA affected: The percentage of the body affected by psoriasis. PASI scores: A measure of the severity of psoriasis. the "DELPHI" consensus dichotomy (DELPHI): A measure of the impact of psoriasis on the patient's quality of life. The dichotomous approach divides all patients into two categories: localized and systemic treatment. Patients requiring systemic treatment met at least one of the following criteria: (1) BSA > 10%; (2) involvement of specific sites; and (3) failure of localized treatment. This method involved a structured communication technique in which expert panelists completed multiple rounds of questionnaires to reach a consensus.

Family history of psoriasis, subjective symptoms, seasonal relationship, and involvement of nails or toenails: including the extent of involvement, site of skin lesion infection (categorized as whole body, scalp, face, trunk, upper limb skin, lower limb skin, palm and toe area skin, joint involvement, and external genital skin involvement), response to previous treatment, follow-up time of the disease. Treatment history, including whether participants had received systemic treatments (such as methotrexate, acitretin, and cyclosporine) or UVB phototherapy, was also noted.

Statistical analysis

Continuous variables data are expressed as the mean $\pm$ standard deviation (mean $\pm$ SD). Categorical variables, such as sex, family history, smoking history, driving history, education level, marital status, incidence, and skin involvement, were displayed as frequencies and percentages (%). These characteristics were used to develop predictive models through both univariate and multivariate regression approaches. In the training cohort, the least absolute shrinkage and selection operator (LASSO) logistic regression was used for multivariate analysis to screen the independent risk factors and build a prediction nomogram for PASI $\geq$ 10. Calibration curves were plotted to assess the calibration of the nomogram. To quantify the discriminative performance of the nomogram, we measured the C-index. In addition, receiver operating characteristic (ROC) curves were used to assess the predictive power of the nomogram, with the area under the ROC calculated. The LASSO method was applied for variable selection to enhance the predictive accuracy and model interpretability. Bootstrapping with 1000 resamples was employed to validate the nomogram and obtain a corrected C-index. Decision curve analysis (DCA) was utilized to assess the clinical utility of the nomogram, providing an assessment of the net return at different threshold probabilities. Statistical analyses were performed using R version 4.3.0 (R Foundation for Statistical Computing, Vienna). All available data were utilized to select characteristics that showed coefficient P values less than 0.05.

Results

Our risk model takes into account available clinical variables (age at visit, sex, weight, and others), all of which were previously identified as significant predictors of moderate-to-severe psoriasis[1,12,16]. This work combined previously identified predictors with newly discovered statistically significant predictors and added the time indicator to the newly developed nomogram.

Univariate logistic regression analysis was performed to assess the association between each individual factor (Course_of_disease, DELPHI, DLQI, BSA, Sex, Age, Height_cm, Weight_kg, BMI, Education, Career, Employment_Status, Marital_Status, Smoking_history, Drinking, Self_perceived_symptoms, Seasonal_relationships, InvolveNail_involvement, Family_history, Nail_involvement_site, Degree_of_nail_and_toenail_involvement, Scalp_involvement, Facial_involvement, palmoplantar_involvement, External_genitalia_involvement, and Arthropathy_involving) and the outcome variable PASI_group (Table 1, Supplementary Tables 1). Subsequently, we applied the LASSO regression analysis (Supplementary Tables 2) for features selection,

Baseline variables	PASI<10 (*N* = 1,004)	PASI ≥ 10 (*N* = 1,105)	Overall (*N* = 2,109)
Age (years) Mean ± SD	39.0 ± 13.3	39.6 ± 14.2	39.3 ± 13.8
Sex (male N %)	618(61.6%)	832(75.3%)	1450(68.8%)
BSA Mean ± SD	10.0 ± 13.7	29.6 ± 21.6	20.3 ± 20.7
Delphi (N %)			
Suitable for local treatment	121 (12.1%)	29 (2.6%)	150 (7.1%)
Suitable for systemic therapy	873 (87.0%)	1068 (96.7%)	1941 (92.0%)
DLQI Mean ± SD	9.66 ± 6.94	14.3 ± 7.14	12.1 ± 7.41
BMI Mean ± SD	24.5 ± 13.5	25.0 ± 5.95	24.8 ± 10.3
Height(cm) Mean ± SD	168 ± 9.71	169 ± 9.63	169 ± 9.70
Weight(kg) Mean ± SD	68.2 ± 14.7	72.0 ± 16.4	70.2 ± 15.7
Family history (N %)	233 (23.2%)	244 (22.1%)	477 (22.6%)
Level of education (N %)			
Bachelor's degree or below	957 (95.3%)	1066 (96.5%)	2023 (95.9%)
Master's degree or above	47 (4.7%)	39 (3.5%)	86 (4.1%)
Career (N %)			
Student	73 (7.3%)	99 (9.0%)	172 (8.2%)
Other	931 (92.7%)	1006 (91.0%)	1937 (91.8%)
Employment status (N %)			
Full-time	738(73.3%)	795(71.8%)	1533(72.5%)
Student	70(7.3%)	92(8.0%)	162(7.7%)
Other	192(19.1%)	224(20.2%)	416(19.7%)
Itching degree (N %)			
Itching	703 (70.0%)	804 (72.8%)	1507 (71.5%)
Pain	20 (2.0%)	10 (0.9%)	30 (1.4%)
Itching and pain	85 (8.5%)	114 (10.3%)	199 (9.4%)
Nail involvement site (N %)			
Toenail or fingernail	193 (19.2%)	226 (20.5%)	419 (19.9%)
Toenail and fingernail	214 (21.3%)	299 (27.1%)	513 (24.3%)
Scalp involvement (N %)	610 (60.8%)	870 (78.7%)	1480 (70.2%)
Facial involvement (N %)	210 (20.9%)	446 (40.4%)	656 (31.1%)
Arthropathy involving (N %)	40 (13.9%)	111 (10.0%)	251 (11.9%)
External genitalia involvement (N %)	100 (10.0%)	132 (11.9%)	232 (11.0%)
Palmoplantar involvement (N %)	145 (14.4%)	269 (24.3%)	414 (19.6%)
Course of disease(months) Mean ± SD	121 ± 90.3	135 ± 90.3	129 ± 90.5

Table 1. Differences clinical characteristics of between PASI <10 and PAS ≥ 10 groups. Note: The measurement data are expressed by mean±standard deviation (Mean±SD); Classification data are expressed in frequency and composition ratio (N %). Abbreviations: BSA: body surface affected area; PASI: psoriasis area and severity index; BMI: body mass index; DLQI: Dermatology Life Quality Index; Family history: family history of plaque psoriasis. The "DELPHI" consensus dichotomy: Delphi consensus from the International Psoriasis Council. Refers to an expert consensus method used to systematically collect and aggregate opinions from a panel of experts to reach a consensus on various aspects of psoriasis treatment and management. The dichotomous approach divides all patients into two categories: localized and systemic treatment. Patients with systemic treatment met at least one of the following criteria: (1) BSA > 10%; (2) involvement of specific sites; and (3) failure of localized treatment. Career-other: Individual household, medical workers, outdoor manual labor, service industry category, staff, computer/electronics, etcetera. Education: Master's degree or above and bachelor's degree or below (elementary school, middle school, high school, secondary students, junior college, and undergraduate). Employment status-other: Retirement, Unemployment, Part-time job.

reducing the number of predictors to 10 (DELPHI, DLQI, BSA, Sex, Weight(kg), Career, Smoking_history, Scalp_involvement, Facial_involvement, Arthropathy_involving (Supplementary Fig. A1, 2, Supplementary Tables 3). Multivariate logistic regression analysis was performed to determine the independent factors significantly associated with PASI_group, while adjusting for potential confounders. Initially, the influence of smoking was considered, which had an odds ratio (OR) of 1.31 and a p-value of 0.062. However, due to its borderline significance and in alignment with clinical insights, smoking history was excluded from the

model. Additionally, patient age at visit was included in the analysis based on its established relevance. The final prediction model, termed "Nomogram-10", incorporated the following statistically significant indicators: DELPHI, DLQI, BSA, Age, Sex, Weight(kg), Career, Scalp_involvement, Facial_involvement, Arthropathy_involving (Fig. 2; Table 2, Supplementary Fig. B, Supplementary Tables 3–3). The predictive equation built for the nomogram was: $h_{(PASI\geq 10)}$ = DELPHI[3.47*Suitable for systemic therapy] + 1.07*DLQI + 1.08*BSA + 1.01*Age at visit + Sex[1.32*Male] + 1.01*Weight(kg) + Career[2.39*Student] + 1.45*Scalp_involvement + 1.42*Facial_involvement + 0.57*Arthropathy_involving.

We evaluated the discriminative power of the constructed prediction model for different patients by comparing the gap between the predicted results and the actual situation. The models were applied to both the internal and external validation cohorts. The C-index of the predicted nomogram was 0.863 (95% CI: 0.848–0.879), which was determined to be 0.860 (95% CI: 0.836–0.885) by bootstrap = 1,000 validation. At the time of testing, the C-index was determined to be 0.910 (95% CI: 0.868–0.953) and 0.951 (95% CI: 0.924–0.977) by external validation cohort 1 and the external validation cohort 2, respectively, indicating that the prediction model had good discrimination (Supplementary Fig. C). The results showed that the constructed prediction model had good predictive ability. To validate the clinical benefit of the model (net benefit for patients with psoriasis), we performed a clinical decision analysis of the predictive nomogram (Supplementary Fig. C). The decision curves show that the risk prediction model was effective in guiding clinical practice. To make our predictive model more accessible to clinicians, we adopted the functionality of DynNom (https://qq2918473747.shinyapps.io/dynnomapp/), which allows our study results to be web browsable in the form of a dynamic nomogram.

Discussion

The long duration and poor outcome of severe psoriasis have long been a challenge for patients. Our study identified 10 risk factors for severe psoriasis (the DELPHI score, the DLQI index, the extent of skin involvement as measured by BSA, the age of the patient at the time of clinical visit, sex, body weight in kilograms, career, the presence of scalp, facial, and arthropathy involvement) associated with disease duration. Research into independent risk factors that may contribute to a patient's progression to severe psoriasis is essential for the development of effective treatment strategies.

In the past, it was commonly believed that the sex ratio among psoriasis patients was not significantly different between males and females[16–19]. However, we found that male psoriasis patients were not only more numerous than females (1450:659 = 2.20:1), but also tended to be older on average. The average age of female psoriasis patients was 38 ± 14 years, whereas that of male patients was 40 ± 13 years, as indicated by our study findings. In addition, a separate study of adults in the United States found that the peak incidence of PASI scores was higher in men around age 50 (ages 40–49), while women tended to have higher scores about a decade later (ages 50–59)[20]. Multivariate analysis has further highlighted a significant gender disparity in the occurrence of severe psoriasis. The analysis shows that males are significantly more likely to suffer from severe psoriasis than females, with an odds ratio of 1.35 (95% CI 1.15–1.57, $p < 0.001$). This result is consistent with a study conducted on a Swedish population of 5,438 individuals, which also found a notably lower median PASI score in

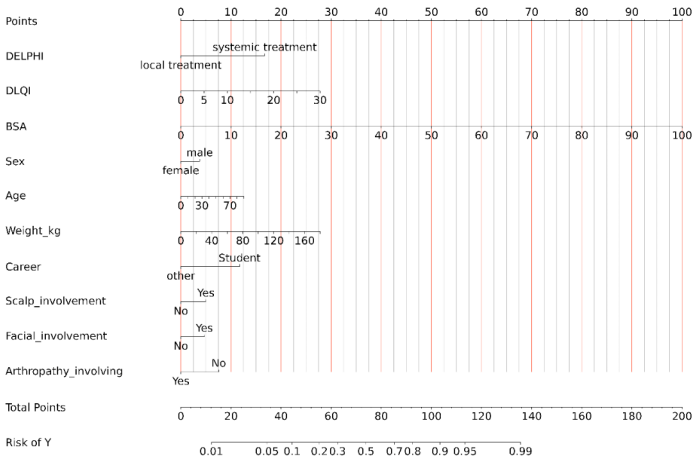

Fig. 2. "Nomogram predicting severity risk of patients with psoriasis." Figure Legend: The risk prediction nomogram for psoriasis patients was developed by incorporating the DELPHI score, the DLQI index, the extent of skin involvement as measured by BSA, the age of the patient at the time of clinical visit, their biological sex, body weight in kilograms, career, the presence of scalp, face, and arthropathy involvement were included. Instructions: Draw a straight line on the axis of the points to figure out how many points the psoriasis patient receives for several of the above risks. Repeat this process for each variable. Add up the scores for each predictor. Find the final sum on the "Total Points" axis. Draw a longitudinal straight line to identify the probability of psoriasis patients suffering from moderate-to-severe diseases (PASI ≥ 10).

Characteristic	Univariable					Multivariable				
	N	Event N	OR[1]	95% CI[1]	p-value	N	Event N	OR[1]	95% CI[1]	p-value
DELPHI										
Local treatment	151	29	—	—	—	151	29	—	—	—
Systemic treatment	1,958	1,076	5.13	3.39, 7.77	<0.001	1,958	1,076	3.47	2.12, 5.69	<0.001
DLQI	2,109	1,105	1.11	1.09, 1.12	<0.001	2,109	1,105	1.07	1.05, 1.09	<0.001
BSA	2,109	1,105	1.09	1.08, 1.10	<0.001	2,109	1,105	1.08	1.07, 1.09	<0.001
Age	2,109	1,105	1.00	1.00, 1.01	0.385	2,109	1,105	1.01	1.00, 1.02	0.020
Sex										
Female	659	273	—	—	—	659	273	—	—	—
Male	1,450	832	1.90	1.58, 2.29	<0.001	1,450	832	1.32	1.02, 1.72	0.037
Weight kg	2,109	1,105	1.02	1.01, 1.02	<0.001	2,109	1,105	1.01	1.00, 1.02	0.006
Career										
Other	1,937	1,006	—	—	—	1,937	1,006	—	—	—
Student	172	99	1.26	0.92, 1.72	0.158	172	99	2.39	1.54, 3.72	<0.001
Scalp involvement										
No	628	234	—	—	—	628	234	—	—	—
Yes	1,481	871	2.40	1.98, 2.91	<0.001	1,481	871	1.45	1.13, 1.86	0.003
Facial involvement										
No	1,452	658	—	—	—	1,452	658	—	—	—
Yes	657	447	2.57	2.12, 3.12	<0.001	657	447	1.42	1.11, 1.82	0.006
Arthropathy involving										
No	1,858	994	—	—	—	1,858	994	—	—	—
Yes	251	111	0.69	0.53, 0.90	0.006	251	111	0.57	0.40, 0.81	0.002

Table 2. The multivariate and univariate Cox regression analysis for psoriasis. [1]OR = Odds Ratio, CI = Confidence Interval. Null deviance = 2,919; Null df = 2,108; Log-likelihood = -1,038; AIC = 2,106; BIC = 2,191; Deviance = 2,076; Residual df = 2,094; No. Obs. = 2,109. Note: Abbreviations: BSA: body surface affected area; PASI: psoriasis area and severity index; BMI: body mass index; DLQI: Dermatology Life Quality Index; Family history: family history of plaque psoriasis. The "DELPHI" consensus dichotomy: Delphi consensus from the International Psoriasis Council. Refers to an expert consensus method used to systematically collect and aggregate opinions from a panel of experts to reach a consensus on various aspects of psoriasis treatment and management. The dichotomous approach divides all patients into two categories: localized and systemic treatment. Patients with systemic treatment met at least one of the following criteria: (1) BSA > 10%; (2) involvement of specific sites; and (3) failure of localized treatment. Career-other: Individual household, medical workers, outdoor manual labor, service industry category, staff, computer/electronics, etcetera. If the odd ratio (OR) for categorical variables is greater than 1, it implies an increased risk of discontinuation, while if it is less than 1, it implies a decreased risk of discontinuation. For variables, an OR greater than 1 indicates that an increase in the value of the variable corresponds to an increased risk of discontinuation, while an OR less than 1 indicates that an increase in the value of the variable corresponds to a decreased risk of discontinuation. We considered a P-value of less than 0.05 to be statistically significant.

women (5.4) as opposed to men (7.3, $p < 0.05$)[21]. Realistic data support our results, showing a further increase in the proportion of males among patients with moderate to severe psoriasis (834:274 = 3.04:1). This is consistent with several recent studies reporting a significantly higher prevalence of moderate to severe disease in men than in women[3,22–26]. Additionally, some literature indicates that a higher incidence of adverse drug events and lower response rates to treatment have been observed in female patients. This emphasizes the importance of considering sex in the selection of precise treatment regimens for psoriasis[3,22–26].

The study revealed a pronounced positive correlation between the severity of psoriasis and body weight. Specifically, patients with more severe forms of psoriasis were found to have a higher body weight than those presenting with milder symptoms (OR 1.01, 95% CI 1.00-1.02, $p = 0.001$). While BMI, an accepted indicator of obesity, and height were not found to have statistical significance in this study, these results suggest that body weight may have a greater impact on the evaluation of disease severity than BMI and height. Furthermore, there is mounting evidence that an increase in weight could elevate the risk of developing moderate-to-severe psoriasis. Similarly, weight reduction is associated with an enhanced response to drug therapy[27–31], reinforcing the influence of weight management on therapeutic outcomes for psoriasis patients. Poor treatment outcomes observed in severely obese patients could be attributed to reduced effective drug concentrations in the body during earlier treatment approaches. Enhancing the dosage for these patients might foster improved clinical outcomes. This underscores the importance of judicious therapeutic dose adjustments in the management of psoriasis in overweight patients, which includes an appropriate escalation in dosage as required[32]. Obesity, an

emblematic presentation of metabolic syndrome, facilitates the release of specific cytokines such as IL-17 and TNF-α from adipocytes, thereby aggravating psoriasis[33,34]. As a result, obesity assumes a bifurcated function: it not only escalates the severity of psoriasis but also impedes the efficacy of therapeutic interventions[33,34]. This finding is corroborated by larger Mendelian randomization studies that link increased BMI, waist, and hip circumferences to a higher risk of psoriasis (ORMR-IVW = 1.63, 1.86, and 1.55 respectively; with respective CIs of 1.32-2, 1.31–2.64, and 1.15–2.07)[35]. Our study underscores the critical role of weight management in the clinical management of psoriasis. It's essential to encourage patients to adopt healthier lifestyles to optimize the success of their treatments. Effective weight management strategies can be a key component in improving both the quality of life and the therapeutic outcomes for individuals with psoriasis[31,32].

Occupational status was another significant predictor, with students exhibiting a higher risk of severe psoriasis (OR 2.39, 95% CI 1.54–3.72, $p < 0.001$). It is widely recognized that stress, including irregular sleep patterns and poor dietary habits, can exacerbate psoriasis and is associated with lifestyles that promote inflammation[36]. Students in high-stress academic environments or those under significant academic pressure may be at an increased risk due to the psychological strain[36–38]. The higher incidence of severe psoriasis among students may be attributed to stress-related factors, although further research is necessary to confirm this hypothesis. However, some studies have suggested that higher levels of education are associated with increased psychological stress and mental strain[36–38], which could potentially worsen psoriasis. This seemingly contradictory phenomenon warrants further investigation.

This study underscores the role of specific clinical features—scalp, face, and arthropathy involvement—in determining the severity of psoriasis. Psoriasis frequently affects the scalp, with approximately 80% of cases involving this area. Our study found that scalp involvement significantly predicts severe psoriasis, with an odds ratio of 1.45 (95% CI 1.13–1.86, $p = 0.003$) and for facial involvement,1 .42 (1.11–1.82, $p = 0.006$). Beyond causing pain and itching, scalp psoriasis presents unique challenges due to the presence of hair, difficulty in treatment application, and poor cosmetic outcomes, leading to significant psychosocial distress[12,39–41]. A growing body of research has consistently demonstrated a correlation between facial involvement and the overall severity of psoriasis in affected individuals. Facial lesions have emerged as a pivotal indicator for assessing the clinical severity of the condition. A recent cross-sectional analysis revealed that the presence of facial lesions in psoriasis patients is indicative of more severe disease manifestations. Patients exhibiting facial psoriasis tend to have notably elevated PASI scores, with an average of 14.0, contrasting sharply with the average PASI score of 6.0 observed in patients without facial involvement[42]. In a comparable cross-sectional examination of the Indian population, a significant association was identified between facial psoriasis, particularly in its mixed form, and an earlier age of onset. This study also reported a substantial increase in systemic PASI scores, with a median value of 8.3, underscoring the heightened severity of the disease in these patients[43].

Interestingly, our study found that arthritis was associated with a reduced likelihood of severe skin manifestations in psoriasis patients (OR 0.57, 95% CI 0.40–0.81, $p = 0.002$). Psoriatic arthritis (PsA) is a complex inflammatory disease that affects approximately 30% of individuals with psoriasis[44]. In many cases, there is little correlation between the severity of musculoskeletal inflammation and the severity of skin or nail psoriasis[44]. This discrepancy suggests that traditional assessments based on the PASI may not fully capture the disease burden in patients with PsA. Therefore, further studies are necessary to better understand the interaction between joint and skin involvement in PsA. Additionally, there is a need to develop a more suitable system for assessing the severity in psoriatic arthritis patients. These factors also result in lower treatment adherence and satisfaction among patients, ultimately making them more prone to developing severe psoriasis[39–41].

The PASI score has been recognized and widely used as an assessment of the extent of psoriasis. Additionally, widely accepted scoring methods (BSA, DLQI, and The "DELPHI" consensus dichotomy) were also found to be strongly correlated with PASI in clinical practice with statistical significance ($p < 0.001$). DLQI is one of the predictors of disease severity, suggesting that the more worried a patient is about the disease, the more likely he or she is to deteriorate, which may be directly related to nervousness and poor mood. The "DELPHI" consensus dichotomy identified patients who were suitable for systemic treatment as predictive of potentially more severe disease. In our model, we chose independent risk variables because they are all easily available in clinical practice and improve the model's predictive capacity.

The model can be used for timely intervention, life coaching, and personalized treatment of patients with psoriasis who may be at risk for developing moderate-to-severe disease, thus reducing their overall risk. The notable strength of this study is the development of a practical and user-friendly predictive model that relies solely on commonly seen clinical features in the real world to determine the likelihood of patients developing moderate-to-severe psoriasis. This predictive model can be easily applied with a QR code or web version (https://qq2918473747.shinyapps.io/dynnomapp/) and can serve as an initial screening tool for moderate-to-severe psoriasis. The nomogram can provide valuable guidance for individualized treatment and long-term monitoring of patients with high-risk moderate-to-severe psoriasis, thus enhancing the effectiveness of clinical practice. The scope and breadth of this study, involving multiple institutions, substantially bolster the robustness of the data and findings. The advantages of such a multicenter approach underline the importance of collaborative efforts in health care research.

Limitations

However, our study has several limitations that need to be acknowledged. Our predictive model does not incorporate individual patient treatment variables, such as medications or treatment regimens. It is an indisputable fact that in the real world, the treatment a patient receives is closely linked to the severity of their condition. The complexity of psoriasis treatment options poses a challenge to our analysis, and our team is diligently seeking solutions. We are looking forward to integrating treatment drugs and regimen metrics into future versions of our model. The retrospective design of this study and the limited sample size have introduced

a potential for selection bias. Enlarging our dataset and incorporating a greater variety of data will improve the precision of our predictive model. While this study has its limitations, it also boasts promising applications. Utilizing this model to assess the severity and progression risk of the disease in patients, and predicting the risk of adverse outcomes in advance, enables the adoption of the optimal treatment strategies at an early stage. This approach should significantly improve outcomes for psoriasis patients.

Conclusion

In summary, the nomogram developed in this study supplies an efficient and easily applicable method for assessing the risk of developing moderate-to-severe psoriasis in patients. This tool has the potential to serve as a personalized and precise aid for dermatologists in the clinical management of disease severity and communication with patients. It is expected to be widely adopted in real-world clinical practice.

Data availability

Data collection was carried out across 12 hospitals: Department of Dermatology, The University of Hong Kong-Shenzhen Hospital, Department of Dermatology, Xinjiang Uygur Autonomous Region People's Hospital, Department of Dermatology, The First Affiliated Hospital of The Fourth Military Medical University, Department of Dermatology, Peking Union Medical College Hospital, Department of Dermatology, Dermatology Hospital of Southern Medical University, Department of Dermatology, Shanghai Skin Disease Hospital, Department of Dermatology, The Second Norman Bethune Hospital of Jilin University, Department of Dermatology, West China Hospital, Sichuan University, Department of Dermatology, Skin Disease Hospital of Tongji University, Department of Dermatology, Hebei Provincial Hospital of Traditional Chinese Medicine, Department of Dermatology, The First Affiliated Hospital of Guangxi Medical University, and Department of Dermatology, Shenzhen People's Hospital. The datasets generated and/or analyzed in this study are not publicly available due to the individual patient sensitivity and patient case confidentiality of the data used in our study, and we regret to inform you that we are unable to share or disclose patients' personal data with outside parties. However, it is available from the corresponding author upon reasonable request.

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Author contributions

Huiwei Wang contributed to all aspects of study design, conduct, data interpretation, and the writing of the manuscript. Jialiang Shi, Suchun Hou, Xiaojing Kang, Chen Yu, Hongzhong Jin, Bin Yang, Yuling Shi, Fuqiu Li, Wei Li, Jun Gu, Mingjun Lei, Youkun Lin, Lin Dang, Jialin Lin, Qing Guo, Gang Wang, Xiaoming Liu contributed to eligibility screening, data extraction from eligible studies, and data analysis and interpretation.

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Declarations

Competing interests

The authors declare no competing interests.

Ethics approval

The research that involved human participants underwent a review and approval process by The University of Hong Kong-Shenzhen Hospital, Guangzhou Shenzhen, China. Participants who took part in the study supplied written informed consent through their legal guardian or next of kin. Reviewed and approved by HKU-SZH Medical Ethics Committee [2019]181.

Informed consent

This study does not involve the use of patient photographs or other identifiable material. All data used in this research are anonymized and do not disclose any personal or sensitive information.

Additional information

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