SKIN

IN-DEPTH REVIEW

Dermatological Manifestations in Parkinson's Disease: A Systematic Review and Single-Arm Meta-Analysis of Prevalence Rates

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ABSTRACT

Introduction: Parkinson's disease (PD) is a progressive neurodegenerative disorder with both motor and non-motor symptoms, including dermatological manifestations that may serve as clinical markers of disease. This study evaluates the prevalence of dermatological manifestations in PD through pooled data, providing refined estimates and insights for clinical practice and future research.
Methods: This review followed PRISMA 2020 and was registered in PROSPERO. PubMed, ProQuest, and EBSCO were searched. Observational studies reporting dermatological prevalence in PD were included. A single-arm meta-analysis was performed with random-effects modeling to estimate pooled prevalence.
Results: A total of 22 studies evaluating dermatological manifestations in PD were analyzed. The combined prevalence rates were as follows: melanoma at 1% (95% CI: 1–2%), non-melanoma skin cancer at 6% (95% CI: 2–10%), actinic keratosis 18% (95% CI: 2–34%), seborrheic dermatitis 23% (95% CI: 7–40%), erythema intertrigo 23% (95% CI: 8–38%), rosacea 15% (95% CI: 4–25%), tinea 17% (95% CI: 0–40%), xerosis 54% (95% CI: 38–71%), hyperhidrosis 37% (95% CI: 18–56%). There was significant variability across most results. Among skin cancers, non-melanoma types, basal cell carcinoma and squamous cell carcinoma, were the most common.
Conclusion: Dermatological manifestations are frequent in PD, with xerosis and hyperhidrosis are the most common. These conditions may represent prodromal markers, supporting the role of routine dermatological assessment in PD and underscoring the need for standardized research to clarify their diagnostic and prognostic value.

INTRODUCTION

Parkinson's disease (PD) is a progressive neurodegenerative disorder marked by the loss of dopaminergic neurons in the substantia nigra, which leads to core motor symptoms such as tremor, bradykinesia, and rigidity.[1] Alongside these, non-motor symptoms, such as sleep disturbances, depression, autonomic dysfunction, and dermatological manifestations have been increasingly recognized as critical

components of PD's clinical spectrum.[2] Skin disorders in PD may reflect underlying neuropathology and serve as early biomarkers of disease progression. Common associated conditions include seborrheic dermatitis, melanoma, and rosacea. Although the mechanisms remain unclear, autonomic dysfunction, altered sebum production, immune dysregulation, and shared genetic or environmental factors are implicated. Additionally, some dermatological changes may result from antiparkinsonian treatments, complicating diagnosis.[3]

Despite growing interest in the dermatological aspects of PD, data on their prevalence and clinical significance remain fragmented. Previous studies vary in design, sample size, diagnostic criteria, and geographic representation, limiting their generalizability.[4] A comprehensive synthesis of existing evidence is needed to better understand the burden and characteristics of dermatological manifestations in PD.

This study aims to evaluate the prevalence of dermatological manifestations observed in patients with PD. By pooling data from diverse studies, we seek to provide a more accurate estimate of their occurrence and highlight potential implications for clinical practice and future research.

METHODS

This systematic review and meta-analysis were conducted in accordance with the Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) 2020 guideline. Additionally, the study was registered in PROSPERO (registration number CRD420251074433) on June 15th, 2025.

Data Sources and Search Strategy

A thorough literature search was performed across PubMed, ProQuest and EBSCO databases from their inception up to June 2025. The search utilized both MeSH terms and free-text keywords related to “Parkinson’s disease,” “skin diseases,” and “dermatological conditions.” Boolean operators and specific database filters, including full-text and peer-reviewed article limitations, were applied. The detailed search strategies are provided in **Supplementary File S1.**

Inclusion and Exclusion Criteria

Studies were eligible for inclusion if they involved adult patients diagnosed with PD, irrespective of disease stage, and reported either point or period prevalence of any dermatological condition. Eligible conditions encompassed, but were not limited to, seborrheic dermatitis, xerosis, hyperhidrosis, rosacea, bullous pemphigoid, melanoma, psoriasis, eczema, and fungal infections. Observational designs, including cross-sectional, cohort, case-control, and case series studies conducted in hospitals, neurology or dermatology clinics, or outpatient settings, were considered. Included studies were required to provide sufficient data to extract or calculate prevalence based on clinical, dermatological, or histopathological evaluation. Excluded were review papers, meta-analyses, editorials, commentaries, letters, conference abstracts, protocols, theses, animal studies, studies lacking full-text access, and those with insufficient quantitative data. Randomized controlled trials were omitted, as they are not designed to determine disease prevalence.

Study Selection and Data Extraction

All identified study titles and abstracts were independently reviewed by the authors. Full-text articles that met the predefined inclusion criteria were then evaluated for eligibility. Any

disagreements regarding study inclusion were resolved through discussion among the authors. Data extraction was performed using a standardized form that captured key information, including the author, publication year, country, study design, sample size, number of patients with skin manifestations, types of dermatological conditions, and diagnostic approaches employed.

Quality Assessment of Included Studies

The methodological quality and potential risk of bias in the included studies were evaluated using assessment tools suitable for their respective study designs. For observational studies, the Newcastle–Ottawa Scale (NOS) was utilized, which assesses studies across three key domains: participant selection, comparability between study groups, and the determination of outcomes or exposures. Based on the overall score, each observational study was categorized as very good, good, satisfactory, or unsatisfactory.

Statistical Analysis

We performed a single-arm meta-analysis to estimate the pooled prevalence of dermatological conditions among PD patients using raw proportions from each study, using the metaprop function from the meta package in R software (version 4.5.1; R Foundation for Statistical Computing, Vienna, Austria). A random-effects model was used to account for between-study heterogeneity. Forest plots were generated to visually display individual and pooled prevalence estimates with 95% confidence intervals (CI). Heterogeneity was quantified using the I^2 statistic, τ^2, and Cochran's Q test. An I2 value less than 25% is considered subtle heterogeneity, between 25% to 50% indicates low heterogeneity, 50%-75% depicts moderate heterogeneity, and more than 75% demonstrates high heterogeneity.

RESULTS

The process of study selection and the results obtained are illustrated (**Figure 1**). A thorough search strategy identified 1821 relevant studies in total. After eliminating duplicates, 1716 studies were left, and 56 studies were selected based on the title and abstract screening according to the inclusion criteria. 27 studies were excluded due to wrong population (n=13), wrong outcome (n=6) and wrong study design (n=8). At last, 22 studies were included in the systematic review, and were used for the single-arm metaanalysis.[5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24,25]

Characteristics and Demographics of the Included Studies

A total of 22 studies published between 2001 and 2024, conducted across multiple regions including Israel, United States, Turkey, Europe, and Korea were included in this systematic review. It consists of cross-sectional and cohort design, enrolled 132,667 patients. The mean age of participants across studies was predominantly in the 60s to 70s, aligning with the typical onset age for PD. PD diagnosis and severity were assessed using a range of tools, most commonly the UK Parkinson's Disease Society Brain Bank Criteria, the Unified Parkinson's Disease Rating Scale (UPDRS), and Hoehn & Yahr staging. Key characteristics of patients included in studies are summarized (**Tables 1, 2 and 3**) present characteristics of the study.

Methodological Quality Evaluation

The quality of all included studies was assessed using the NOS for cross-sectional, cohort & case control designs. The results of these assessments are summarized (**Supplementary File S3, S4, S5).** The

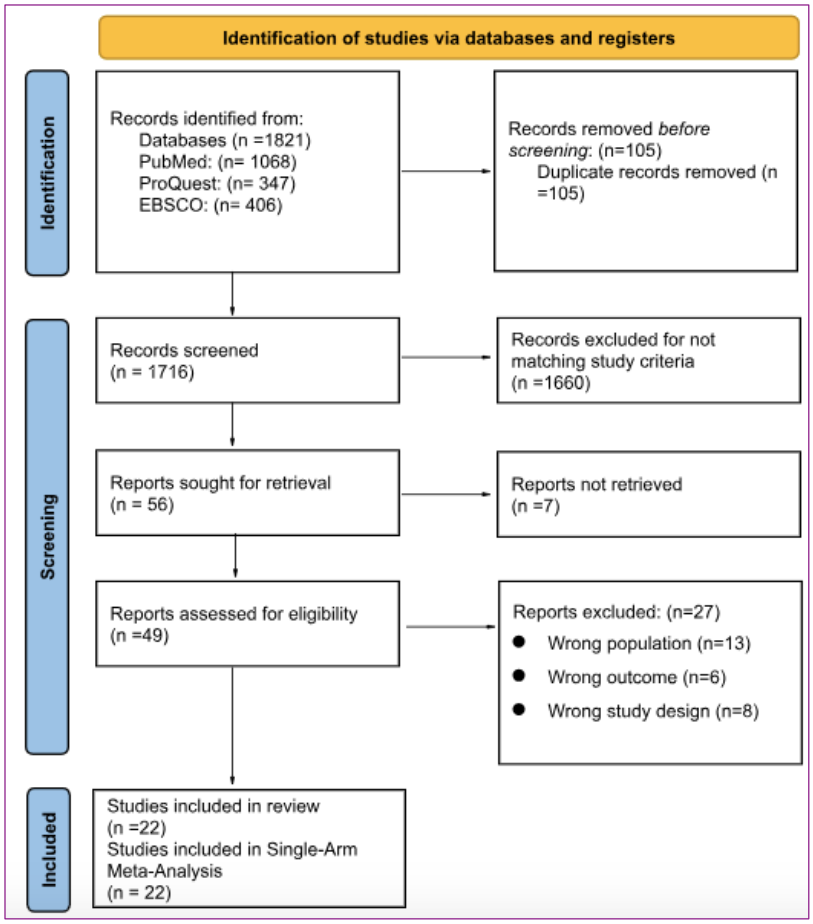

Figure 1. PRISMA 2020 flow diagram

Table 1. Study Demographics

Author, Year	Country	Study Design	Sample Size	Age (Mean ± SD)	Gender		Onset of PD	PD Measurement
					Male	Female		
Azizi, 2024	Israel	Cross-sectional	141	71.7 +- 7.3 years	87	54	N/A	UK PD Society Brain Bank's neurological criteria
Bertoni, 2010	US	prospecti ve cohort	2106	68.6			7.1	N/A
Constant inescu, 2015	US	retrospect ive cohort	1737	Nonmela noma= 61.7 (9.6) Melano ma= 65.9 (8.0)	N/A	N/A	≤ 5 years	N/A
Dalvin et al., 2017	US	Cohort	974	75 ± 10	561	413	N/A	Neurologist-confirmed diagnosis

Dinesh, 2021	International, multicenter	Cohort	423	61.7 years (SD: ± 9.71 years)	277	146	6.77 months (SD: ± 6.79 months)	Unified Parkinson's Disease Rating Scale
Driver, 2007	US	cohort	487	59.7			N/A	N/A
Elbaz, 2005	US	cohort	196	72 years at diagnosis (range, 42–97 years)	121	75	71 years at onset of PD (range, 41–97 years)	The Rochester Epidemiology Project
Ferreira, 2007	Portugal	cross-sectional	150	66+-9	87	63	N/A	the UK Brain Bank for idiopathic PD
Fischer, 2001	German	Cross-sectional	70	66.3 ± 9.8	40	30	N/A	Hoehn & Yahr scale + clinical exam
Inzelberg, 2012	Israel	Cross-sectional	490	69.5 ± 11.2	N/A	N/A	9.5 ± 6.9	N/A
Iyidal, 2024	Turkey	Cross-sectional	215	65.15 ± 9.8 years	143	72	Med (range) 4 (2-7) years	Hoehn & Yahr staging system
Jucevičiūtė et al., 2019	Lithuania	Pilot study	32	67 (61.3–77.0)	9	23	N/A	N/A
Olsen, 2006	Denmark	Case control, registry based	8090	73	4263	3827	N/A	the national Danish Hospital Register (ICD-8/10)
Olsen, 2007	Denmark	cohort	14,088	N/A	7,190	6,898	N/A	Medical records
Plouvier et al., 2014	Netherlands	Nested case-control	86	72.3	49	37	2 years	UK Parkinson's Disease Society Brain Bank Criteria
Rugbjerg, 2012	US	cohort	20343	72.7	N/A	N/A	0-4 years	N/A
Ryu et al., 2020	South Korea	Cohort	70780	71.58 ± 9.62	29544	41236	N/A	UK Parkinson's Disease Society Brain Bank Criteria
Shahid et al., 2020	Pakistan	Cross-sectional	107	61 ± 14 years	N/A	N/A	3 ± 1 year	Self-administrated questionnaire Patients from neurology

								outpatient department
Swinn, 2003	UK	Cross-sectional, survey	77	62.8+-10.8	51	26	age at onset: 50+-12.2	UK Parkinson's Disease Society Brain Bank clinical criteria for PD
Tomic, 2022	Croatia	Cross-sectional	61	Median IQR: 69.0 (61.5–73.5) years	39	22	Median IQR: 7.0 (3.0–10.5) years	Unified Parkinson's Disease Rating Scale
Van Wamelen., 2019	UK	Cross-sectional	228	62.6 ± 10.8	155	73	5.7 ± 4.7 years	1. PDQ-8 (a specific instrument for assessment of health-related quality of life in PD) 2. PD Sleep Scale-version 1 (PDSS)
Wirdefeldt, 2013	Swedia	cohort	11,786	62.5 (SD), 9.2)	N/A	N/A	N/A	N/A

Abbreviation: N/A, Not Available

Table 2. Characteristics of Included Studies

Author, Year	Study Design	Sample Size	Age (Mean ± SD)	Dermatology Condition			
				Neoplastic	Inflammatory	Infectious	Other
Azizi, 2024	Cross-sectional	141	71.7 +-7.3 years	Melanoma, BCC, SCC, Actinic Keratosis	N/A	N/A	N/A
Bertoni, 2010	Prospective cohort	2106	68.6	Melanoma, BCC, SCC, Actinic Keratosis, Melanocytic Nevus	N/A	N/A	N/A
Constantinescu, 2015	Retrospective cohort	1737	Nonmelanoma= 61.7 (9.6) Melanom	Melanoma	N/A	N/A	N/A

			a= 65.9 (8.0)				
Dalvin et al., 2017	Cohort	974	75 ± 10	Melanoma	N/A	N/A	N/A
Dinesh, 2021	Cohort	423	61.7 years (SD: ± 9.71 years)	Melanoma, BCC, SCC	Psoriasis, Seborrheic Dermatitis, Rosacea	N/A	N/A
Driver, 2007	Cohort	487	59.7	Melanoma	N/A	N/A	N/A
Elbaz, 2005	Cohort	196	72 years at diagnosis (range, 42–97 years)	Melanoma	N/A	N/A	N/A
Ferreira, 2007	Cross-sectional	150	66+-9	BCC, Actinic Keratosis, Melanocytic Nevus, Dysplastic Nevus	N/A	N/A	N/A
Fischer, 2001	Cross-sectional	70	66.3 ± 9.8	N/A	Seborrheic Dermatitis, Atopic Dermatitis, Rosacea, Acne Vulgaris, Erythema Intertrigo	Tinea	N/A
Inzelberg, 2012	Cross-sectional	490	69.5 ± 11.2	Melanoma	N/A	N/A	N/A
Iyidal,	Cross-	215	65.15 ±	Cherry Angioma,	Seborrheic	Tinea	Hyperh

2024	sectional		9.8 years	Actinic Keratosis	Dermatitis, Rosacea, Erythema Intertrigo, Other Eczema,		idrosis, Xerosis
Jucevičiūtė et al., 2019	Pilot study	32	67 (61.3–77.0)	N/A	N/A	N/A	Sunburn Often, Xerosis
Olsen, 2006	Case control, registry based	8090	73	Melanoma, BCC, SCC	N/A	N/A	N/A
Olsen, 2007	cohort	14,088	N/A	Melanoma, NMSC, BCC, SCC	N/A	N/A	N/A
Plouvier et al., 2014	Nested case-control	86	72.3	N/A	N/A	N/A	Hyperhidrosis
Rugbjerg, 2012	cohort	20343	72.7	Melanoma	N/A	N/A	N/A
Ryu et al., 2020	Cohort	70780	71.58 ± 9.62	Melanoma, NMSC	N/A	N/A	N/A
Shahid et al., 2020	Cross-sectional	107	61 ± 14 years	Melanoma	Seborrheic Dermatitis, Bullous pemphigoid, Rosacea	N/A	Other
Swinn, 2003	Cross-sectional, survey	77	62.8+-10.8	N/A	N/A	N/A	Hyperhidrosis
Tomic, 2022	Cross-sectional	61	Median IQR: 69.0 (61.5–73.5)		Seborrheic Dermatitis		

			years				
Van Wamelen., 2019	Cross-sectional	228	62.6 ± 10.8	N/A	N/A	N/A	Hyperhidrosis
Wirdefeldt, 2013	Cohort	11,786	62.5 (SD), 9.2)	Melanoma	N/A	N/A	N/A

Abbreviation: NMSC, Non-Melanoma Skin Cancer; BCC, Basal Cell Carcinoma; SCC, Squamous Cell Carcinoma; N/A, Not Available

Table 3. Summary of dermatological findings in PD patients

Dermatological Findings	Number of Studies	Proportion	95% Confidence Interval	Heterogeneity (I^2)
Xerosis	2	0.54	0.38-0.71	70.2%
Hyperhidrosis	4	0.37	0.18-0.56	96.1%
Seborrhoeic Dermatitis	5	0.23	0,07-0.40	97.8%
Erythema intertrigo	2	0.23	0.08-0.38	83.8%
Actinic keratosis	4	0.18	0.02-0.34	97.9%
Tinea	2	0.17	0.00-0.40	96.8%
Rosacea	4	0.15	0.04-0.25	95.8%
Non-melanoma skin cancer	7	0.06	0.02-0.10	99.1%
Melanoma	15	0.01	0.01-0.02	95.6%

overall quality of the studies ranged from fair to good.

Prevalence of Dermatological Manifestations in Parkinsons Disease

Melanoma

15 studies reporting melanoma prevalence in PD patients were included, representing 131.818 individuals. The pooled prevalence of melanoma was 1% (95% CI: 1%–2%).[5,6,7,8,9,10,11,12,13,14,15,16,17,18,19]

Non-melanoma

Seven studies involving a total of 95,778 participants were included in the analysis of non-melanoma skin cancer (NMSC) prevalence among individuals with PD.[5,7,12,17,18,19,20] NMSC in this context provides skin cancer, non-categorized as melanoma, also, basal cell carcinoma (BCC), and squamous cell carcinoma (SCC). The pooled prevalence of NMSC was 6% (95% CI: 2%–10%). Overall, heterogeneity for NMSC was also substantial (I^2 = 99.1%, p < 0.0001), indicating significant variability in study populations, case ascertainment, and outcome definitions.

Actinic keratosis

Four studies reported actinic keratosis manifestation in a total of 2612 PD patients. The pooled prevalence was 18% (95% CI: 2%-34%; I^2 = 97.9%, p < 0.0001) with individuals ranging from 1% (Bertoni, 2010) to 41% (Azizi, 2024).[5,12,20,2]

Seborrheic dermatitis (SD)

Five studies reported the prevalence of SD in PD patients, including 876 patients. The

pooled prevalence was 23% (95% CI: 7%–40%) with high heterogeneity (I^2 = 97.8%, p < 0,0001). Individuals ranged from 2% (Dinesh, 2021) to 47% (Shahid, 2020), showing variability in populations.[2,6,15,16,21]

Erythema Intertrigo

Two studies with a total of 285 PD reported the prevalence of erythema intertrigo. The pooled prevalence was 23% (95% CI: 8%–38%). Individual study estimates ranged from 16% (Iyidal, 2024) to 31% (Fischer, 2001). This also showed substantial heterogeneity (I^2 = 83.8%, p < 0,0129), indicating variability between studies.[15,21]

Rosacea

Studies with a total of 815 PD patients with rosacea showed that the pooled prevalence was 15% (95% CI: 4%-25%; I^2 = 95.8%, p < 0.0001). Prevalence across individual studies varied ranging from 3% (Dinesh, 2021) to 27% (Iyidal, 2024).[6,15,16,21]

Tinea

Two studies, including a total of 285 PD patients, assessed the prevalence of tinea infection. The pooled prevalence was 17% (95% CI: 0%–40%). Individual study estimates varied from 6% (Fischer, 2001) to 29% (Iyidal, 2024). Heterogeneity was very high (I^2 = 96.8%, p < 0.0001), indicating considerable variability between studies.[15,21]

Xerosis

Two studies with 247 PD patients reported the prevalence of xerosis. The meta-analysis yielded a pooled prevalence of 54% (95% CI: 38%–71%). The estimates ranged from 44% (Jucevičiūtė, 2021) to 61% (Iyidal, 2024). There was substantial heterogeneity (I^2 = 70.2%, p = 0.0670).[21,22]

Hyperhidrosis

Five studies provided data on hyperhidrosis, encompassing a total of 676 patients with PD. The combined prevalence was 37% (95% CI: 18%–56%), with individual study rates ranging from 9% (Plouvier, 2014) to 64% (Swinn, 2003). The analysis indicated substantial heterogeneity (I^2 = 96.1%, p < 0.0001).[15,21,23,24,25]

DISCUSSION

Dermatological changes are frequently seen in PD patients, yet they are often overlooked by healthcare professionals. Skin issues in PD significantly impact a patient's overall well-being and often contribute to reduced self-esteem.[6] Among skin cancers, NMSC including BCC and SCC were the most commonly reported. Among non-cancerous skin conditions, the most frequently reported were xerosis, affecting over half of the patients, followed by SD and erythema intertrigo. (**Figure 2**)

Cutaneous disorders in PD can be classified as (1) non-iatrogenic, such as melanoma, seborrheic dermatitis, sweating abnormalities, bullous pemphigoid, and rosacea, and (2) iatrogenic, resulting from antiparkinsonian therapies like levodopa, dopamine agonists, amantadine, or delivery methods such as apomorphine injections, intestinal gel, and deep brain stimulation. Some conditions, including seborrheic dermatitis and sweating abnormalities, may stem from peripheral autonomic dysfunction and precede motor symptoms. α-Synuclein, a key protein in PD pathogenesis, is also present in skin tissue, where its misfolding and aggregation may contribute to these non-motor manifestations.[26]

Epidemiological and genetic studies indicate a higher prevalence of skin cancers in PD, particularly non-melanoma types such as BCC and SCC. Our meta-analysis supports this, identifying NMSC as the most common

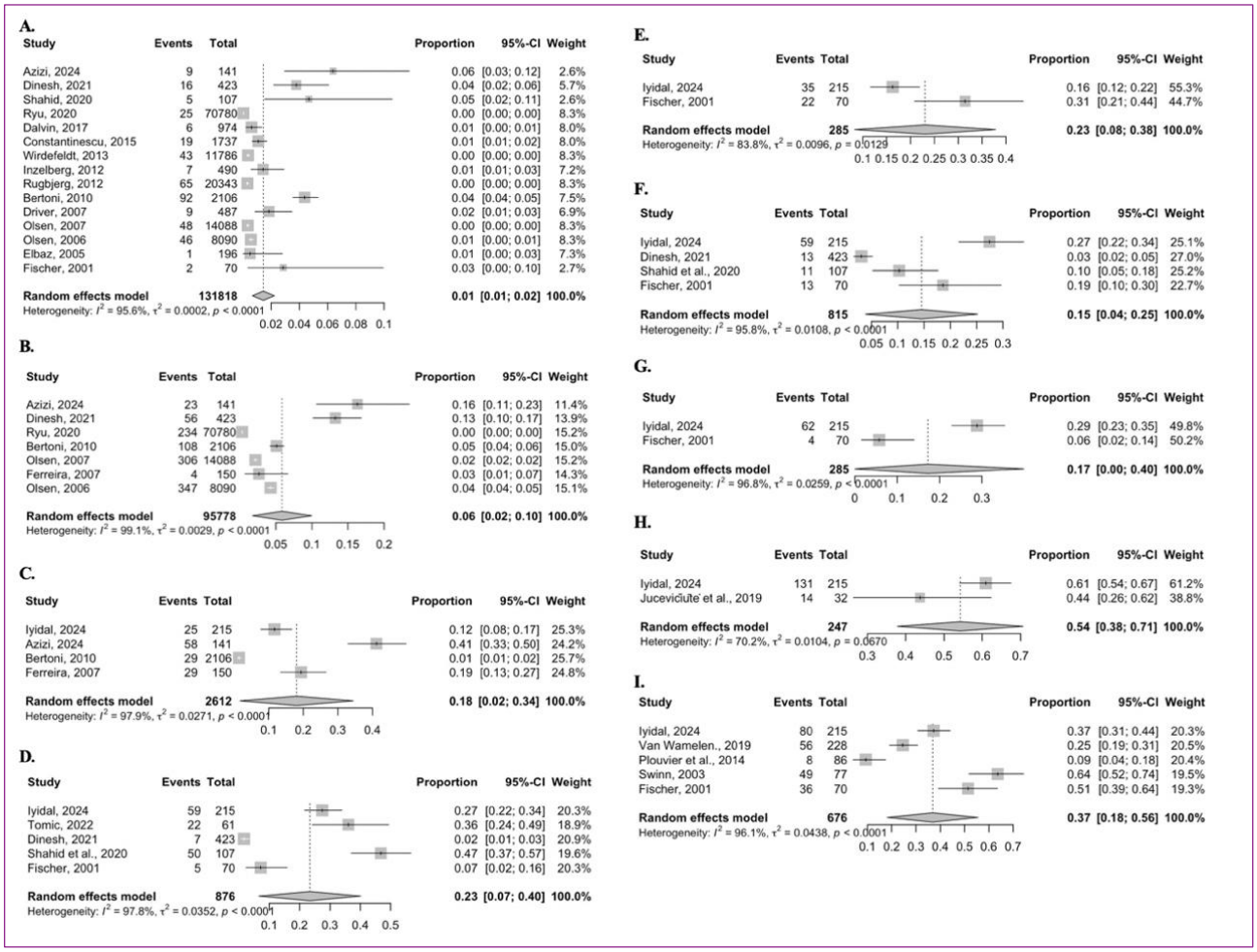

Figure 2. Forest plot showing the pooled prevalence of (A) Melanoma, (B) Non Melanoma, (C)Actinic Keratosis, (D) Seborrhoeic Dermatitis (SD), (E) Erythema Intertrigo, (F) Rosacea, (G) Tinea, (H) Xerosis, (I) Hyperhidrosis manifestations in Parkinson's disease patients.

skin cancer in PD, aligning with Krasowska et al., who reported a significantly increased risk of BCC and a slight increase for SCC. Melanoma, though less common, also shows a significant association with PD.[27] According to a meta-analysis by Zhang et al., individuals with PD had a 75% higher risk of developing melanoma, reinforcing a consistent epidemiological link observed across different populations.[28]

Shared pathogenic mechanisms may explain the link between PD and skin cancers. A key hypothesis involves the melanocortin 1 receptor (MC1R) gene variants, which influence pigmentation and are expressed in both melanocytes and dopaminergic neurons. These variants increase susceptibility to melanoma and NMSCs, particularly in fair-skinned individuals, and may interact with UV exposure, a known skin cancer risk factor. MC1R dysregulation may thus connect pigmentation pathways with dopaminergic neurodegeneration.[27,28] Actinic keratosis (AK) among PD patients showed a pooled prevalence of 18% (95% CI: 2%-34%; I^2 = 97.9%, $p < 0.0001$). Azizi et al. in his study demonstrated that the most frequently observed skin tumor in over 40% of participants was AK and significantly higher than basal cell carcinoma (BCC).[5] However,

Iyidal et al., stated that there was no increased incidence of AK in PD patients.[21]

Other dermatology findings such as SD, erythema intertrigo and rosacea also showed an increase in PD patients. Cowley et al. stated before that reduced mobility leads to sebum accumulation contributing to SD. Hypomimia may stimulate sebum production, promoting Malassezia growth, which is linked to SD. Similar patterns were found in psychiatric patients with neuroleptic-induced parkinsonism, where SD prevalence was higher among those with motor symptoms. In Tomic et al. study, SD was observed in 36.1% PD patients and showed a positive correlation with both advancing age and the severity of motor symptoms.[2] Iyidal et al., reported that erythema intertrigo were significantly more often seen among PD patients experiencing hyperhidrosis compared to those without it.[21] In PD, neuroinflammation involves elevated MMP-3 and MMP-9, contributing to neuronal loss, while a genetic variant increasing MMP-9 expression raises neurodegeneration risk. Rosacea patients also show increased MMP activity in the skin, leading to inflammation and tissue damage, suggesting a possible shared inflammatory mechanism.[29]

This meta-analysis found a 17% prevalence (95% CI: 0–40%) of tinea infections in PD patients, with high study heterogeneity (I^2 = 96.8%). Iyidal et al. reported tinea pedis at 14.4% and tinea unguium at 14.9%, while Fischer et al. observed a lower onychomycosis rate of 5.7%.[15,21] Tinea in PD is linked to autonomic dysfunction and hyperhidrosis, which promote a moist environment for fungal growth, a significant association between hyperhidrosis and tinea infections. PD pathology, including autonomic nerve degeneration and alpha-synuclein accumulation in the skin, may impair local immunity and skin barrier function, increasing fungal susceptibility.[21] Altered skin pH and thermoregulation further weaken defenses. Tinea is a relevant yet often overlooked dermatological issue in PD, reflecting underlying autonomic dysfunction.[15]

Iyidal et al. reported that xerosis often appears before motor symptoms and is linked to early PD stages. Its pathophysiology likely involves autonomic dysfunction, aging, and alpha-synuclein accumulation in the skin, which may impair sebum regulation and skin barrier function.[21] Jucevičiūtė et al. also found higher rates of dry skin in PD patients, supporting the role of alpha-synuclein in sebaceous gland dysfunction. Xerosis is a consistent non-motor symptom of PD with potential relevance to disease development.[22] This meta-analysis found a pooled prevalence of 37% (95% CI: 18%–56%) for hyperhidrosis in PD patients, with high heterogeneity (I^2 = 96.1%). Hyperhidrosis is a common autonomic symptom in PD, occurring in the prodromal phase or alongside motor symptoms.[21,24] Its pathophysiology involves dopaminergic neuron loss and alpha-synuclein accumulation, disrupting autonomic regulation of sweat glands.[15,21,23] Hyperhidrosis is more frequent in PD than in the general population and often coexists with other autonomic issues and motor fluctuations. In some cases, excessive sweating appears before PD diagnosis, potentially serving as an early non-motor sign.[24]

Limitations

This review has several limitations. Significant heterogeneity among studies, due to variations in design, populations, diagnostic criteria, and dermatological assessment methods, limits the precision of pooled prevalence estimates. Some conditions, such as xerosis, tinea, and

erythema intertrigo, were reported in few studies, reducing the strength of conclusions. Most data originated from Western and Asian populations, with limited representation from low- and middle-income countries, affecting generalizability. Additionally, several studies relied on self-reported dermatological diagnoses, introducing potential bias. Future research should apply standardized definitions, include diverse populations, and prospectively examine the link between dermatological signs and PD progression.

CONCLUSION

This systematic review and single-arm meta-analysis highlights the high prevalence and diversity of dermatological manifestations in PD, with xerosis (54%) and hyperhidrosis (37%) being the most common. Although less frequent, melanoma (1%) and non-melanoma skin cancers (6%) are clinically significant. The substantial heterogeneity across studies reflects differences in diagnostic criteria and study populations. Given the frequency of these manifestations, integrating routine dermatological assessments into PD management is essential for comprehensive patient care. Future research should aim to standardize methodologies to further explore the clinical implications of these cutaneous symptoms.

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Supplementary File S1. Search Strategy

Database	Query	Results
PubMed Filter: Full text, Clinical Trial	1. (((Parkinson Disease[MeSH Terms]) OR (Parkinson's disease[Title/Abstract])) OR (Parkinson disease[Title/Abstract])) OR (parkinsonism[Title/Abstract]) 2. ("Skin Diseases"[Mesh] OR "Dermatological conditions" OR "Skin disorders" OR "seborrheic dermatitis" OR “xerosis” OR “hyperhidrosis” OR “rosacea” OR "bullous pemphigoid" OR “melanoma” OR “psoriasis” OR “eczema” OR "skin cancer" OR "skin manifestations")	158,256 1,384,037
	#1 AND #2	1,068
ProQuest Filter: Full text, peer reviewed Source type: scholarly journals	1. ("Parkinson's disease" OR "Parkinson disease" OR “parkinsonism”) 2. ("Skin Diseases" OR "Dermatological conditions" OR "Skin disorders" OR "seborrheic dermatitis" OR “xerosis” OR “hyperhidrosis” OR “rosacea” OR "bullous pemphigoid" OR “melanoma” OR “psoriasis” OR “eczema” OR "skin cancer" OR "skin manifestations")	47,949 104,782
	#1 AND #2	347
EBSCO Filter: Full Text, Peer reviewed, Academic journals	1. ("Parkinson's disease" OR "Parkinson disease" OR “parkinsonism”) 2. ("Skin Diseases" OR "Dermatological conditions" OR "Skin disorders" OR "seborrheic dermatitis" OR “xerosis” OR “hyperhidrosis” OR “rosacea” OR "bullous pemphigoid" OR “melanoma” OR “psoriasis” OR “eczema” OR "skin cancer" OR "skin manifestations") #1 AND #2	15,388 7,902 406
Total		1821

Supplementary File S2. PECOTS-SD

Patients	Adults diagnosed with Parkinson’s disease, any stage of disease progression
Exposure	Presence of any dermatological condition, including but not limited to seborrheic dermatitis, xerosis, hyperhidrosis, rosacea, bullous pemphigoid, melanoma, psoriasis, eczema, and fungal infections
Comparator	None (single-arm meta-analysis focusing on prevalence within PD population)

Outcomes	Prevalence of dermatological conditions in PD patients, measured as point prevalence or period prevalence based on study data; diagnostic methods include clinical examination, dermatological assessment, or histopathology where available
Time	No time restriction.
Setting	Patients attending any medical facilities (neurology clinics, dermatology clinics, general hospitals, outpatient or inpatient)
Study Design	Observational studies including cross-sectional, cohort, case series, and case-control studies reporting prevalence or frequency data of dermatological conditions in PD

Supplementary File S3. Newcastle-Ottawa Scale (NOS) for cross-sectional designs

Study	Selection				Comparability	Outcome		Total	Conclusion
	Representativeness of the sample	Sample size	Non-respondents	Ascertainment of the exposure	Comparability of subjects in different outcome groups	Assessment of outcome	Statistical test		
Ferreira, 2007	-	-	*	**	**	**	*	8	Good Studies
Inzelberg, 2012	*	-	-	**	**	-	*	6	Satisfactory Studies
Swinn, 2003	-	-	*	**	**	-	*	6	Satisfactory Studies
Fischer, 2001	*	-	*	**	**	-	*	7	Good Studies
Iyidal, 2024	*	-	-	**	*	-	*	5	Satisfactory Studies
Azizi, 2024	*	-	*	**	**	*	*	8	Good Studies
Tomic, 2022	*	-	-	**	**	*	*	7	Good Studies
Shahid, 2020	*	-	*	**	-	*	*	6	Satisfactory Studies

Jucevičiūtė, 2019	*	-	-	*	*	*	*	5	Satisfactory Studies
Van Wamelen, 2019	*	-	*	**	*	*	*	7	Good Studies

Very Good Studies: 9-10 points; Good Studies: 7-8 points; Satisfactory Studies: 5-6 points; Unsatisfactory Studies: 0 to 4 points

Supplementary File S4. Newcastle-Ottawa Scale (NOS) for cohort designs

Study	Selection (4 stars)				Comparability (2 stars)	Outcome (3 stars)			Total
	Representativeness of the exposed cohort	Selection of the non exposed cohort	Ascertainment of exposure	Demonstration that outcome of interest was not present at start of study	Comparability of cohorts on the basis of the design or analysis	Assessment of outcome	Was follow-up long enough for outcomes to occur	Adequacy of follow up of cohorts	
Dinesh, 2021	*	*	*	*	*	*	*	-	Good quality
Ryu, 2020	*	*	*	*	*	*	*	-	Good quality
Rugbjerg, 2012	*	-	*	-	*	*	*	*	Fair quality
Elbaz 2005	*	*	*	*	**	*	*	*	Good quality
Dalvin et al., 2017	*	*	*	*	**	*	*	*	Good quality
Constantinescu, 2015	*	*	*	-	*	*	*	-	Fair quality
Wirdefeldt, 2013	*	*	*	*	**	*	*	*	Good quality
Bertoni, 2010	*	*	*	*	**	*	*	*	Good quality
Driver, 2007	*	*	*	*	**	*	*	*	Good

									quality
Olsen, 2007	*	*	*	-	*	*	*	-	Fair quality

Good quality: 3 or 4 stars in selection domain AND 1 or 2 stars in comparability domain AND 2 or 3 stars in outcome/exposure domain
Fair quality: 2 stars in selection domain AND 1 or 2 stars in comparability domain AND 2 or 3 stars in outcome/exposure domain
Poor quality: 0 or 1 star in selection domain OR 0 stars in comparability domain OR 0 or 1 stars in outcome/exposure domain

Supplementary File S5. Newcastle-Ottawa Scale (NOS) for case control designs

Author, year Case Control Studies	Selection (4 stars)				Comparability (2 stars)	Exposure (3 stars)			Total
	Is the case definition adequate?	Representativeness of the exposed cases	Selection of controls	Definition of Control	Comparability of cohorts on the basis of the design or analysis	Assessment of exposure	Same method of ascertainment for cases and controls	Non-Response rate	
Plouvier et al., 2014	*	*	*	*	*	*	*	*	Good quality
Olsen 2006	*	*	*	*	*	*	*	*	Good quality

Good quality: 3 or 4 stars in selection domain AND 1 or 2 stars in comparability domain AND 2 or 3 stars in outcome/exposure domain
Fair quality: 2 stars in selection domain AND 1 or 2 stars in comparability domain AND 2 or 3 stars in outcome/exposure domain
Poor quality: 0 or 1 star in selection domain OR 0 stars in comparability domain OR 0 or 1 stars in outcome/exposure domain