Remote severity assessment in atopic dermatitis: Validity and reliability of the remote Eczema Area and Severity Index and Self-Administered Eczema Area and Severity Index

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Background: Reliable assessment of atopic dermatitis (AD) severity is necessary for clinical practice and research. Valid and reliable remote assessment is essential to facilitate remote care and research.

Objectives: Assess the validity and reliability of the Eczema Area and Severity Index (EASI) based on images and patient-assessed severity based on the Self-Administered EASI (SA-EASI).

Methods: Whole-body clinical images were taken during consultation from children with AD. After consultations, caregivers completed the SA-EASI and provided images from home. Four raters assessed all images twice using EASI.

Results: A total of 1534 clinical images and 425 patient-provided images were collected from 87 and 32 children. Excellent (0.90) validity, good inter (0.77) and intrarater reliability (0.91), and standard error of measurement (4.31) was found for the EASI based on clinical images. Feasibility of patient-provided images showed limitations with missing images (43.8%) and quality issues (23.1%). However, good validity (0.86), inter (0.74) and intrarater reliability (0.94) were found when assessment was possible. Moderate correlation (0.60) between SA-EASI and EASI was found.

Limitations: Low portion patient-provided images.

Conclusion: AD severity assessment based on images strongly correlates with in-person AD assessment. Good measurement properties confirm the potential of remote assessment. Moderate correlation between SA-EASI and in-person EASI suggest limited value of self-assessment. (JAAD Int 2023;13:184-91.)

Key words: atopic dermatitis; clinical outcome measure; Eczema Area and Severity Index; medical dermatology; telemedicine; validated pediatric dermatology.

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INTRODUCTION

Atopic dermatitis (AD) is the most common chronic inflammatory skin disease.[1] Hallmarks of AD include pruritus and recurrent eczematous skin lesions.[2] These symptoms can affect daily life including sleep, social interaction, and other activities.[3,4] In addition to patients' symptoms and preferences, treatment is based on clinical symptoms, ie, degree of erythema, edema, excoriations, lichenification, location, and extent.[5,6] Assessment of clinical signs is therefore important.

Remote assessment is becoming increasingly relevant as the movement for telehealth, remote trials is advancing.[7] Telehealth could be an efficient tool for disease management.[8,9] Remote trials could be less expensive, less burdensome and more inclusive than traditional trials as it enables patients living in remote areas to participate.[10] Furthermore, research may benefit from quantifying outcomes based on images derived from clinical care. In all these cases, reliable remote assessment is necessary. However, our current knowledge of the validity and reliability of remote assessment remains limited. Research into remote assessment has investigated the reliability of high-quality images of target lesions in artificial settings.[11] Although promising, results of this study cannot be directly adopted as whole-body assessment is needed in clinical practice and research. Recently a few studies explored the validity of remote assessment in AD based on whole-body images. However, these studies did not investigate important measurement properties, such as inter and intrarater reliability, measurement error, had short interval periods between in-persons and remote assessment which could cause recall bias, or did not include patients with severe AD.[12-14] Additionally, the only study investigating patient-provided images recruited patients by providing them an incentive, which could have led to inclusion of a selected motivated and digitally proficient population.[14] Results of this study can therefore not be directly extrapolated. To confirm the potential of remote assessment in AD, all measurement properties need to be investigated based on images containing the full spectrum of AD, all Fitzpatrick skin types, skin conditions and based on full body images.

For assessment of AD, the Harmonising Outcome Measures for Eczema initiative recommends using the Eczema Area and Severity Index (EASI) in clinical practice and research.[15,16] The EASI is based on the extent of each affected region and severity of each sign (ie, erythema) per region. This information is key in developing a treatment plan in clinical practice. The representation of these aspects emphasizes the significance of the EASI as an outcome measure for AD severity. Until now, the measurement properties of the EASI has only been studied based on in-person assessments.

In addition, it would be interesting to investigate the ability of patients to report their AD severity. For this purpose, the Self-Administered EASI (SA-EASI) was developed.[17] However, the role of the SA-EASI has been investigated to a limited extent.[17,18]

CAPSULE SUMMARY

- Reliable assessment of atopic dermatitis severity is necessary for clinical practice and research. Current knowledge on remote assessment remains limited.
- This study confirmed the potential of remote severity assessment of atopic dermatitis based images and provide the foundation for remote assessment in clinical practice and research.

Objectives

To assess the validity and reliability of the remote EASI based on clinical images and to investigate the construct validity of the SA-EASI.

METHODS

Setting and design

This prospective observational study was conducted at an academic outpatient clinic for children with atopic diseases. Children diagnosed with AD and their caregivers were invited to participate in this study. All children with AD were eligible, except when caregivers were unable to understand Dutch.

During consultation, AD severity was assessed using EASI.[16] Afterward, clinical images were taken with a Sony Cybershot DSC-RX100 (compact camera; Sony Corporation) by the same investigator from all body regions (head, trunk, upper extremities, and lower extremities) and individual AD lesions. After consultation, caregivers completed a survey containing patient-reported outcome measurements (PROMS) and SA-EASI.[17,19-24] Finally, caregivers were asked to photographed their child's AD at home. For this purpose, caregivers received a simple instruction guide (Supplementary Appendix 1, available via Mendeley at https://data.mendeley.com/datasets/r73xs6kpbb/1). An overview of the study design is provided in Supplementary Table I

Abbreviations used:

AD:	atopic dermatitis
EASI:	Eczema Area and Severity Index
ICC:	intraclass correlation coefficient
PROMS:	patient-reported outcome measurements
SA-EASI:	Self-Administered Eczema Area and Severity Index
SEM:	standard error of measurement

(available via Mendeley at https://data.mendeley.com/datasets/r73xs6kpbb/1).

Severity assessment by raters

At least 4 weeks after collecting all images, both clinical images and patient-provided images were independently assessed by 4 raters twice with an interval of at least 4 weeks. Raters were instructed to assess all images, however raters could skip images deemed too blurry for assessment. All images of a single patient were clustered to reflect daily practice. For assessment of AD severity the EASI was used.[16]

Statistical analysis

All data were analyzed using SPSS (version 26; IBM Corp). Validity of the remote EASI based on clinical images and patient-provided images was assessed by comparison with the in-person EASI using intraclass correlation coefficient (ICC) (2.1) metrics.[25] Bland and Altman were made to visualize agreement between remote and in-person EASI scores.[26] Proportional bias was evaluated by conduction a regression analyses with the difference between assessments as dependent variable and mean EASI as independent variable. Systematic bias was assessed by conducting a *t* test for the difference between EASI and remote EASI. Additionally, inter and intrarater reliability was evaluated based on ICC (2.1) metrics. ICC values <0.5 indicate poor, values between 0.5 and 0.75 moderate; values between 0.75 and 0.9 good; and values >0.90 excellent reliability.[25] No methods were used to improve reliability. Standard error of measurement (SEM) was calculated as using the formula: $\sqrt{(\sigma^2}$ measurements + σ^2 error).[27] Two subgroup analyses were performed. First children were divided based on Fitzpatrick skin type into a light skin group (Fitzpatrick skin types I-III) and a dark skin group (Fitzpatrick skin type IV-VI).[28] For the second subgroup analysis children were divided into 2 age groups (<8 years and ≥8 years) to investigate if relative differences in body surface areas of regions influence assessment. For analysis of the relation between the accuracy of AD severity assessment and AD severity, standard deviation of each child's remote EASI score were correlated using Spearman correlation coefficient to the average remote EASI score. Correlation between EASI, SA-EASI, and other PROMS was evaluated using Spearman correlation coefficient.[29] For classification of AD severity, children were stratified based on in-person EASI scores into a clear (EASI 0), mild (EASI 0,1-5,9), moderate (EASI 6,0-22,9), and severe (EASI 23,0-72,0) group.[30] Handling of missing data and sample size calculation are described in Supplementary Appendix 3 and Supplementary Appendix 4 (available via Mendeley at https://data.mendeley.com/datasets/r73xs6kpbb/1).

RESULTS

Patient and clinical image characteristics

Overall, 110 children were randomly approached to participate in the study. In total 87 children were included (Table I). Median age was 7 years and half (53%) were female. All skin types were represented in our study, skin type II was most common (41%) (Supplementary Table II). All AD severities were represented, with the highest prevalence of moderate AD severity (47%). A total of 1534 clinical images were collected from 87 children and 425 patient-provided images from 32 children. The quality of up to 89% of all patient-provided images was high enough for assessment. For some body parts almost half of the caregivers (44%) did not provide images. Therefore, total body AD severity assessment based on patient-provided images was only possible for 13 children (41%) (Supplementary Table III, available via Mendeley at https://data.mendeley.com/datasets/r73xs6kpbb/1). With a prevalence of up to 20%, post inflammatory hyper- and hypopigmentation were the most common skin conditions interfering with AD assessment.

Criterion validity

Criterion validity of remote assessment based on clinical images. Assessment of clinical images showed excellent (0.90) agreement between in-person and remote EASI scores (Table II and visualized in a Bland and Altman plot in Supplementary Fig 1, *A*, available via Mendeley at https://data.mendeley.com/datasets/r73xs6kpbb/1). No systematic difference between in-person and remote EASI was found, indicating that raters do not assess AD more or less severe on clinical images as compared with in-person. Additionally, no proportional bias was found, thus AD severity does not affect agreement between in-person and remote EASI. Investigation of the 5 children outside the limits of agreement showed that 4 out of 5 children have dark skin (Fitzpatrick skin type V-VI) of which 2 had severe

Table I. Overview of patient and clinical image characteristics (n = 87)

Item	Outcome
Patient characteristics	
Age (y), median (IQR)	7 (4-12)
Sex (female), % (n)	53.4 (47)
Fitzpatrick skin type, % (n)	
I-III	59.8 (52)
IV-VI	40.0 (35)
Allergic rhinitis, % (n)	46.0 (40)
Asthma, % (n)	28.7 (25)
Disease severity of AD based on EASI (n = 86), % (n)	
Clear	2.3 (2)
Mild	34.1 (30)
Moderate	46.6 (41)
Severe	14.8 (13)
Current therapy, % (n)	
Mild to potent TCS	82.8 (72)
Very potent TCS	10.3 (9)
Topical calcineurin inhibitor	27.6 (24)
Systemic therapy	4.6 (4)
EASI (n = 85), median (IQR)	8.8 (3-20)
POEM (n = 79), median (IQR)	12.5 (6-17)
NRS peak itch during last 24 h (n = 82), median (IQR)	5 (2-8)
Quality of life, median (IQR)	
DLQI (n = 8)	4 (1- 7)
CDLQI (n = 40)	5 (2-13)
IDQOL (n = 27)	5 (1-10)
RECAP (n = 81), median (IQR)	10 (5-17)
Clinical image characteristics	
Clinical images (n = 87)	
Photographs per patient, median (IQR)	18 (14-21)
Conditions possibly influencing assessment, % (n)	
PIH	20 (17)
Acne vulgaris	7 (6)
Folliculitis	7 (6)
Other*	8 (7)
Patient-provided images	
Number of participants, % (n)	36.8 (32)
Photographs per patient, median (IQR)	12 (9-17)
Conditions possibly influencing assessment, n (%)	
PIH	16 (5)
Acne vulgaris	6 (2)
Other*	9 (3)
Days between consultation and images, median (IQR)	3 (1-4)

AD, Atopic dermatitis; *CDLQI*, Children's Dermatology Life Quality Index; *DLQI*, Dermatology Life Quality Index; *EASI*, Eczema Area and Severity Index; *IDQOL*, Infant Dermatitis Quality of Life; *IQR*, interquartile range; *NRS peak itch*, Numeric Rating Scale for peak itch; *PIH*, postinflammatory hypo/hyperpigmentation; *POEM*, Patient Oriented Eczema Measure; *RECAP*, Recap of atopic eczema; *TCS*, topical corticosteroids.
*Other conditions include ichthyosis vulgaris, keratosis pilaris, and skin atrophy. Total numbers may not add up due to missing values.

post inflammatory hyper- and hypopigmentation and 1 acne vulgaris. Subgroup analyses based on skin type showed no significant differences in agreement between in-person and remote EASI for children with dark skin (0.84) as compared with light skin (0.95). Additionally, subgroup analyses showed no differences between children younger (0.89) and older than 8 years old (0.89).

Criterion validity of remote assessment based on patient-provided images. Evaluation of patient-provided images showed good agreement (0.86) with in-persons AD assessment (Table II and Bland and Altman plot [Supplementary Fig 1, *B*, available via Mendeley at https://data.mendeley.com/datasets/r73xs6kpbb/1]). Furthermore, no systematic difference or proportional bias was found. Due to a small number of patients that provided whole-body images, we decided to perform 2 additional *post hoc* analyses. First, we performed an analysis in which we assumed that patients that did not provide images of all body regions had no active AD on the sites of which no images were provided and found moderate agreement (0.64; n = 29). For the second analysis, we evaluated the criterion validity of subscores of the remote EASI for each body region and found varying criterion validity with scores ranging from 0.49 to 0.86 in samples containing up to 29 children (Supplementary Table IV, available via Mendeley at https://data.mendeley.com/datasets/r73xs6kpbb/1).

Reliability of remote assessment

Interrater reliability. Assessment of clinical images showed good interrater reliability (0.77) (Table II). Interrater reliability was highest for region scores and lowest for lichenification scores

Table II. Feasibility of remote assessment

Item	Outcome	
Validity of remote assessment — ICC		
Clinical images (n = 78)	0.90 (0.85-0.94)	
Fitzpatrick skin type I-III (n = 45)	0.95 (0.91-0.97	
Fitzpatrick skin type IV-VI (n = 33)	0.84 (0.70-0.92)	
Children <8 y (n = 42)	0.89 (0.81-0.94)	
Children ≥8 y (n = 36)	0.89 (0.79-0.94)	
Bias	Outcome	P value
Systematic difference*	0.29 (−0.74 to 1.33)	.58
Proportional bias†	−0.03	.58
Patient-provided images (n = 13)	0.86 (0.59-0.95)	
Bias	Outcome	P value
Systematic difference*	−0.6 (−4.52 to 3.32)	.75
Proportional bias†	−0.11	.54
Interrater reliability — ICC	First assessment	Second assessment
Clinical images (n = 76/71)	0.77 (0.59-0.87)	0.88 (0.83-0.92)
Fitzpatrick skin type I-III (n = 45)	0.80 (0.59-0.89)	
Fitzpatrick skin type IV-VI (n = 33)	0.74 (0.53-0.86)	
Children <8 y (n = 41)	0.75 (0.54-0.87)	
Children ≥8 y (n = 35)	0.75 (0.51-0.87)	
Patient-provided clinical images (n = 10/9)	0.74 (0.41-0.92)	0.87 (0.63-0.97)
Standard error of measurement	First assessment	Second assessment
Clinical images‡ (n = 76)	4.31	2.92
Patient-provided clinical images‡ (n = 10)	5.56	3.13
Intrarater reliability — ICC		
Clinical images (n = 71)	0.91 (0.89-0.93)	
Fitzpatrick skin type I-III (n = 45)	0.88 (0.68-0.94)	
Fitzpatrick skin type IV-VI (n = 31)	0.91 (0.70-0.97)	
Children <8 y (n = 39)	0.87 (0.65-0.94)	
Children ≥8 y (n = 36)	0.89 (0.66-0.96)	
Patient-provided clinical images (n = 9)	0.94 (0.87-0.97)	

ICC, Intraclass correlation coefficient.

*Systematic difference is expressed as difference between the in-person EASI and remote EASI.

†Proportional bias is expressed as the unstandardized regression coefficient of a regression with as dependent variable the difference between the in-person and remote EASI, and as independent variable the mean of the in-person and remote EASI. A small coefficient represents a small effect of AD severity on agreement between the in-person and remote EASI.

‡The SEM is expressed as EASI score and resembles the standard deviation between raters.

(Supplementary Table V, available via Mendeley at https://data.mendeley.com/datasets/r73xs6kpbb/1). The SEM, a value that represents the standard deviation for measurements, was 4.31. The relation between AD severity and the difference between raters is visualized in Supplementary Figure 2 (available via Mendeley at https://data.mendeley.com/datasets/r73xs6kpbb/1). The difference between raters increased when AD severity increases (r_s = 0.88). After second assessment interrater reliability improved (0.88) and SEM decreased to 2.92 points on the EASI scale. Subgroup analysis showed no differences in interrater reliability between children with light (n = 45; ICC 0.80) and dark skin (n = 31; ICC 0.74). No differences were found between young (n = 41; 0.75) and older children (n = 35; ICC 0.75).

Interrater reliability based on patient-provided images was moderate 0.74 (Table II, Supplementary Table VI, available via Mendeley at https://data.mendeley.com/datasets/r73xs6kpbb/1). Further *post hoc* analysis of the subscores for each region (that contain a larger sample) show varying interrater reliability ranging from 0.48 to 0.84. The SEM for remote EASI based on patient-provided clinical images was 5.56.

Intrarater reliability. Reassessment of images showed excellent intrarater reliability for both clinical (0.91) and patient-provided images (0.94), Table II (Supplementary Table VII and VIII, available via Mendeley at https://data.mendeley.com/datasets/r73xs6kpbb/1). Further analysis of the subscores of patient-provided images for each region (that contain a larger sample size) show good intrarater

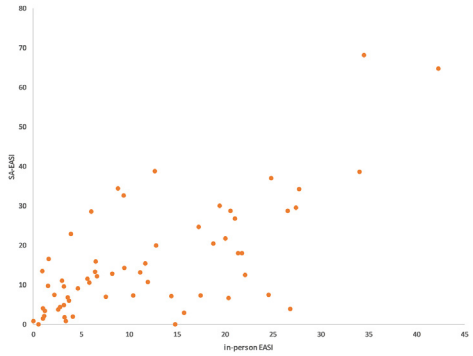

Fig 1. Correlation between in-person EASI and SA-EASI. Scatter plot between the in-person EASI and SA-EASI. Each dot resembles a patient. Note that the SA-EASI scores cannot be compared directly with EASI scores as the SA-EASI is a different outcome measure with a different scale that ranges from 0 to 96, whereas the EASI ranges from 0 to 72.

reliability (range 0.79-0.85). Subgroup analysis of clinical images showed no difference in intrarater reliability between children with light (n = 45; ICC 0.88) and dark skin (n = 31; 0.91), and between young (n = 39; ICC 0.87) and older children (n = 36; ICC 0.89).

Patient self-assessment of AD

Correlation between EASI and SA-EASI was moderate (n = 62; r_s = 0.60) (Fig 1). Correlation between AD severity and all other PROMS was lower (Supplementary Table IX, available via Mendeley at https://data.mendeley.com/datasets/r73xs6kpbb/1). Exploration of outliers (children with greatest discrepancy between SA-EASI and in-person EASI) showed that the 5 most positive outliers (higher SA-EASI than EASI) all have high peak pruritus scores (mean 8.1, SD 1.3), whereas the 5 most negative outliers (lower SA-EASI than EASI) report low pruritus scores (mean 3.1, SD 2).

DISCUSSION

Principal findings

In this study, we investigated remote assessment in AD. We confirmed that remote assessment based on images strongly correlates with in-person AD assessment. Additionally, we identified aspects; image quality, skin type, and presence of other skin conditions that could limit assessment. Inter- and intrarater reliability of remote AD assessment showed consistency in assessments, suggesting potential for remote severity assessment of AD in clinical practice and research. Finally, we investigated self-assessment and found that the validity of these assessments may be limited as compared with existing PROMS.

Remote assessment based on high-quality images could be used as a good alternative to in-person severity assessment. We found excellent agreement between in-person AD assessment and assessment based on clinical images. These findings are in line with other smaller studies that show similar results for assessment of severity signs (ie, erythema and excoriation) and total EASI scores based on high-quality images.[11-14] Additionally, we investigated reliability of remote assessment and found higher reliability and similar SEM compared with previous studies investigating reliability of in-person AD assessment.[31,32] Overall, these findings confirm that remote assessment can be used in clinical practice and research.

Health professionals using remote assessment should notice that skin type, presence of other skin conditions and quality of images, can affect assessment. Previous research into AD assessment showed poor reliability in patients with dark skin.[33] In our study, we noted that dark skin was more common in cases that showed greater disagreement. However, overall assessment of AD severity in children with dark skin showed good measurement properties, confirming the validity of remote assessment in children with dark skin. More experience with and representation of dark skin in dermatology may improve assessment.[34]

An important factor that influences assessment is quality of images. Although, our main goal was to investigate if remote assessment is possible, we believe that our findings offer some insights in the feasibility of remote assessment as well. We noted that up to half of patient-provided images were of insufficient quality or were incomplete (ie, images of body regions were missing). This could be a major limitation to remote assessment. However, participants in our study had no incentive to provide high-quality and whole-body images as they already received consultation. In contrast to our study, Croce et al[14] found no issues with quality of patient-provided images in a population that received an incentive. Additionally, Croce et al[14] reported willingness to adopt remote assessment. We therefore assume that remote severity assessment is possible in some populations and care providers and researchers should discuss remote assessment with patients individually. Further research to develop methods to ensure high-quality images for AD assessment could enhance adoption of remote assessment. For example, augmented-reality supported tools with interactive instructions could help patients to capture high-quality images.

Strengths and limitations

The current study has several strengths. First of all, this is a large study containing over 1900 images of 87 children and the whole AD severity spectrum. Additionally, all skin types and skin conditions were represented in our study. Second, this is the first study investigating remote assessment at a professional and patient level. A limitation of this study is the low portion of participants that sent (whole-body) images. Although this could be interpreted as low willingness to adopt remote care, we previously showed satisfaction with remote care.[9] We therefore assume that low participation results from a lack of incentive to participate as children already received consultation. Finally, we did not included adults with AD which could limit the generalizability of our findings.

CONCLUSION

In conclusion, we showed that remote AD severity assessment strongly correlates with in-person assessment. In addition, we showed a good measurement properties of the remote EASI. Remote assessment can be used as an alternative to in-person assessment in both clinical practice and research. However, despite its potential, feasibility issues with patient-provided images may limit its use for select cases. More research is necessary to ensure high-quality assessment based on patient-provided images. Finally, we showed only moderate correlation between the SA-EASI and in-person EASI, indicating limited value of self-assessed of clinical signs.

We would like to thank our patients for participating in this study.

Conflicts of interest

None disclosed.

REFERENCES

1. Bylund S, Kobyletzki LB, Svalstedt M, Svensson Å. Prevalence and incidence of atopic dermatitis: a systematic review. *Acta Derm Venereol*. 2020;100(12):adv00160.
2. Weidinger S, Beck LA, Bieber T, Kabashima K, Irvine AD. Atopic dermatitis. *Nat Rev Dis Primers*. 2018;4(1):1.
3. Silverberg JI, Gelfand JM, Margolis DJ, et al. Patient burden and quality of life in atopic dermatitis in US adults: a population-based cross-sectional study. *Ann Allergy Asthma Immunol*. 2018;121(3):340-347.
4. Ben-Gashir MA, Seed PT, Hay RJ. Quality of life and disease severity are correlated in children with atopic dermatitis. *Br J Dermatol*. 2004;150(2):284-290.
5. Wollenberg A, Kinberger M, Arents B, et al. European guideline (EuroGuiDerm) on atopic eczema: part I — systemic therapy. *J Eur Acad Dermatol Venereol*. 2022;36(9):1409-1431.
6. Wollenberg A, Kinberger M, Arents B, et al. European guideline (EuroGuiDerm) on atopic eczema — part II: non-systemic treatments and treatment recommendations for special AE patient populations. *J Eur Acad Dermatol Venereol*. 2022;36(11):1904-1926.
7. Kennedy J, Arey S, Hopkins Z, et al. Dermatologist perceptions of teledermatology implementation and future use after COVID-19: demographics, barriers, and insights. *JAMA Dermatol*. 2021;157(5):595-597.
8. Armstrong AW, Johnson MA, Lin S, Maverakis E, Fazel N, Liu FT. Patient-centered, direct-access online care for management of atopic dermatitis: a randomized clinical trial. *JAMA Dermatol*. 2015;151(2):154-160.
9. Ragamin A, de Wijs LEM, Hijnen DJ, et al. Care for children with atopic dermatitis in the Netherlands during the COVID-19 pandemic: lessons from the first wave and implications for the future. *J Dermatol*. 2021;48(12):1863-1870.
10. Fogel DB. Factors associated with clinical trials that fail and opportunities for improving the likelihood of success: a review. *Contemp Clin Trials Commun*. 2018;11:156-164.
11. Ali Z, Joergensen KM, Andersen AD, et al. Remote rating of atopic dermatitis severity using photo-based assessments: proof-of-concept and reliability evaluation. *JMIR Form Res*. 2021;5(5):e24766.
12. Hughes ME, Aralis H, Bruhn KW, et al. A reliability study using Network-Oriented Research Assistant to evaluate the use of digital photographs in the assessment of atopic dermatitis. *J Am Acad Dermatol*. 2021;85(3):725-726.
13. Ali Z, Chiriac A, Bjerre-Christensen T, et al. Mild to moderate atopic dermatitis severity can be reliably assessed using smartphone-photographs taken by the patient at home: a validation study. *Skin Res Technol*. 2022;28(2):336-341.
14. Croce EA, Rathouz PJ, Lopes FCPS, et al. Validation of remote atopic dermatitis severity assessment with the Eczema Area and Severity Index in children using caregiver-provided photos and videos. *Pediatr Dermatol*. 2022;39(4):547-552.
15. Schmitt J, Spuls PI, Thomas KS, et al. The Harmonising Outcome Measures for Eczema (HOME) statement to assess clinical signs of atopic eczema in trials. *J Allergy Clin Immunol*. 2014;134(4):800-807.
16. Hanifin JM, Baghoomian W, Grinich E, Leshem YA, Jacobson M, Simpson EL. The Eczema Area and Severity Index-A practical guide. *Dermatitis*. 2022;33(3):187-192.
17. Housman TS, Patel MJ, Camacho F, Feldman SR, Fleischer AB Jr, Balkrishnan R. Use of the Self-Administered Eczema Area and Severity Index by parent caregivers: results of a validation study. *Br J Dermatol*. 2002;147(6):1192-1198.
18. van Velsen SG, Knol MJ, Haeck IM, Bruijnzeel-Koomen CA, Pasmans SG. The Self-administered Eczema Area and Severity Index in children with moderate to severe atopic dermatitis: better estimation of AD body surface area than severity. *Pediatr Dermatol*. 2010;27(5):470-475.
19. Charman CR, Venn AJ, Williams HC. The patient-oriented eczema measure: development and initial validation of a new tool for measuring atopic eczema severity from the patients' perspective. *Arch Dermatol*. 2004;140(12):1513-1519.
20. Yosipovitch G, Reaney M, Mastey V, et al. Peak Pruritus Numerical Rating Scale: psychometric validation and responder definition for assessing itch in moderate-to-severe atopic dermatitis. *Br J Dermatol*. 2019;181(4):761-769.
21. Finlay AY, Khan GK. Dermatology Life Quality Index (DLQI)—a simple practical measure for routine clinical use. *Clin Exp Dermatol*. 1994;19(3):210-216.

22. Lewis-Jones MS, Finlay AY. The Children's Dermatology Life Quality Index (CDLQI): initial validation and practical use. *Br J Dermatol*. 1995;132(6):942-949.
23. Lewis-Jones MS, Finlay AY, Dykes PJ. The Infants' Dermatitis Quality of Life Index. *Br J Dermatol*. 2001;144(1):104-110.
24. Howells LM, Chalmers JR, Gran S, et al. Development and initial testing of a new instrument to measure the experience of eczema control in adults and children: recap of atopic eczema (RECAP). *Br J Dermatol*. 2020;183(3):524-536.
25. Koo TK, Li MY. A guideline of selecting and reporting intraclass correlation coefficients for reliability research. *J Chiropr Med*. 2016;15(2):155-163.
26. Bland JM, Altman DG. Statistical methods for assessing agreement between two methods of clinical measurement. *Lancet*. 1986;1(8476):307-310.
27. de Vet HC, Terwee CB, Knol DL, Bouter LM. When to use agreement versus reliability measures. *J Clin Epidemiol*. 2006;59(10):1033-1039.
28. Fitzpatrick TB. The validity and practicality of sun-reactive skin types I through VI. *Arch Dermatol*. 1988;124(6):869-871.
29. Zar JH. *Spearman Rank Correlation: Overview*. Wiley StatsRef: Statistics Reference Online; 2014.
30. Chopra R, Vakharia PP, Sacotte R, et al. Severity strata for Eczema Area and Severity Index (EASI), modified EASI, Scoring Atopic Dermatitis (SCORAD), objective SCORAD, Atopic Dermatitis Severity Index and body surface area in adolescents and adults with atopic dermatitis. *Br J Dermatol*. 2017;177(5):1316-1321.
31. Bożek A, Reich A. Assessment of intra- and inter-rater reliability of three methods for measuring atopic dermatitis severity: EASI, objective SCORAD, and IGA. *Dermatology*. 2017;233(1):16-22.
32. Silverberg JI, Lei D, Yousaf M, et al. What are the best endpoints for Eczema Area and Severity Index and Scoring Atopic Dermatitis in clinical practice? A prospective observational study. *Br J Dermatol*. 2021;184(4):888-895.
33. Zhao CY, Wijayanti A, Doria MC, et al. The reliability and validity of outcome measures for atopic dermatitis in patients with pigmented skin: a grey area. *Int J Womens Dermatol*. 2015;1(3):150-154.
34. Alvarado SM, Feng H. Representation of dark skin images of common dermatologic conditions in educational resources: a cross-sectional analysis. *J Am Acad Dermatol*. 2021;84(5):1427-1431.