

Report

Pilot testing and validation of an atopic dermatitis screening and evaluation questionnaire

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Introduction

Atopic dermatitis (AD) is a chronic inflammatory skin condition characterized by immune dysfunction and skin barrier abnormalities.^{1,2} Symptoms may include intense pruritus, xerosis, lichenification, erythema, and eczematous lesions that commonly affect the flexural creases. AD is a major problem worldwide, affecting approximately 10–20% of children and 3% of adults,³ and is currently the eighth most common disease in individuals under 25.⁴ Over the past 30 years, the prevalence of AD has increased two- to threefold in industrialized nations,⁵ and this number has continued to rise.⁶

Given its rising prevalence, there is a pressing need to study the epidemiology of AD. To this end, multiple studies have been conducted to determine the incidence, prevalence, and environmental factors that contribute to the disease.^{7–10} However, many of these epidemiological studies rely on self-reported AD diagnosis,^{7,8,10} which may not be optimal in the absence of a clinician diagnosis.¹¹ Given

Abstract

Background Atopic dermatitis (AD) is a major public health concern worldwide. Given its rising prevalence, there is a pressing need to study its epidemiology. To date, no validated, cost-effective, and patient self-administered screening instrument exists that can reliably distinguish AD from other skin conditions. Our aim is to develop an instrument that can validate a self-reported AD diagnosis quickly and with reasonable accuracy in a population at a distance.

Methods A one-page, 13-question atopic dermatitis screening and evaluation questionnaire (ADSEQ) was generated after literature review and consultation with dermatologists. The questionnaire was administered to 121 patients with and without AD in a dermatology clinic. Sensitivity, specificity, positive predictive value, and negative predictive value were calculated for all questions. The questions with the highest sensitivities were selected for logistic regression analysis, and a receiver operating characteristics curve was plotted.

Results Four scoring algorithms using different combinations of responses were then developed. A combination of Q7 (itching) and Qpic (the image questions combined) had the highest sensitivity (96.3%) and specificity (84%) for a diagnosis of AD. Cronbach's alpha coefficient was 0.71, indicating acceptable internal consistency. Other algorithms combining Qpic and questions about past diagnosis (Q1) or family history of atopy (Q5) also had sensitivities and specificities in the 80s or 90s.

Conclusions In this pilot study, we found that our questionnaire was a valid and reliable self-administered tool for distinguishing individuals with AD from individuals without AD.

the impracticality of getting a board-certified dermatologist to examine every study participant (high cost and low feasibility), a tool that can validate a self-reported AD diagnosis quickly and with reasonable accuracy and reliability in a remote population is needed. In response to this need, we have developed an atopic dermatitis screening and evaluation questionnaire (ADSEQ). While the ADSEQ is not meant to replace an evaluation by a dermatologist, the tool was designed to validate self-reported AD diagnosis, assess self-reported AD severity, and measure itch severity. In this study, we report results from pilot testing of the ADSEQ in a clinic population of patients with dermatologist-diagnosed AD as well as individuals without AD.

Materials and methods**Instrument design**

The ADSEQ tool was designed to be a brief one-page questionnaire that could be completed quickly and easily (Fig. 1). Thirteen questions were generated from a review of

ATOPIC DERMATITIS SCREENING AND EVALUATION QUESTIONNAIRE (ADSEQ)

1. Have you *ever* been diagnosed with eczema or atopic dermatitis by a: (choose all that apply)

☐ Doctor who is not a dermatologist (primary care doctor, pediatrician, or other doctor)

☐ Nurse practitioner or physician's assistant

☐ Dermatologist

☐ I have never been diagnosed with eczema or atopic dermatitis → Please proceed directly to QUESTION 4

2. How old were you when your eczema or atopic dermatitis: (please write down exact age in years)

a. was first diagnosed _____; b. was most severe _____; c. cleared completely _____ (if never cleared, check this box ☐)

3. When your eczema or atopic dermatitis was at its worst, did you have: (check one only)

☐ Very little rash ☐ Only a few scattered patches that could be covered by 1 or 2 palms of your hands

☐ Scattered patches that could be covered by 3 or 4 palms ☐ Scattered patches that could be covered by 5 to 10 palms

☐ Extensive patches that could be covered by 11 to 20 palms ☐ Very extensive patches that could be covered by 20+ palms

4. Have you *ever* had doctor-diagnosed: (choose all that apply)

☐ Asthma ☐ Seasonal allergies or hayfever ☐ Food allergies ☐ None of the above

5. Did your mother, father, brother, sister, or child *ever* have: (choose all that apply)

☐ Asthma ☐ Seasonal allergies or hayfever ☐ Food allergies ☐ Eczema or atopic dermatitis ☐ None of the above

6. Do you generally have dry skin? ☐ NO ☐ YES

7. Does your skin itch frequently?

☐ NO ☐ YES → How intense is the itch (on average and at its worst) on a scale from MILD to SEVERE? (Mark an X on each line that best indicates the level of itch).

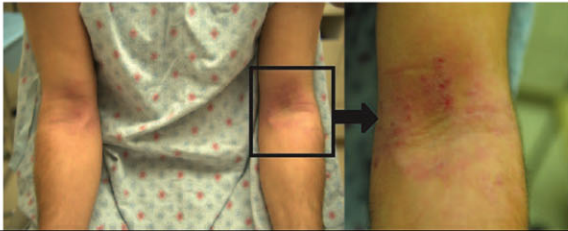
On average? Mild itch _____ Severe itch

At its worst? Mild itch _____ Severe itch

→ How often does the itch keep you up at night? ☐ Never in the past year ☐ Less than one night per week ☐ One or more nights per week

8. Have you had a similar rash to the picture below on the folds of your elbows, behind your knees, or in front of your ankles?

☐ NO ☐ YES



9. Have you had a similar rash on the back of your hands?

☐ NO ☐ YES



10. Have you had a similar rash around your neck, eyes or ears?

☐ NO ☐ YES



11. Have you had a similar rash on your feet or heels?

☐ NO ☐ YES



12. If you have had similar rashes to those pictured, please check the most typical location(s) of your rashes (choose all that apply):

☐ Head and neck ☐ Chest and belly ☐ Back ☐ Arms (upper limbs) ☐ Legs (lower limbs) ☐ Palms ☐ Soles ☐ Genitals

13. If you have had similar rashes to those pictured, have you ever noticed silvery scales over the skin lesions? ☐ NO ☐ YES

THANK YOU!

Figure 1 The Atopic Dermatitis Screening and Evaluation Questionnaire

the literature and expert opinion by board-certified dermatologists. Four of the questions (Q8–Q11, collectively referred to as Qpic) were accompanied by representative pictures of AD on five different body locations. One question (Q7) was accompanied by two 10 cm long subscales ranging from “Mild itch” to “Severe itch.”

Study population

Institutional review board approval was obtained before the administration of this questionnaire to patients at Brigham and Women's Hospital (BWH; Boston, MA, USA). Eligible participants were English-speaking individuals over the age of 18. Patients were recruited by study staff over a 2-month period without account for age, sex, or ethnic group. All patients were given the questionnaire for self-administration in patient rooms either before or after an appointment with a board-certified dermatologist. All participants provided their informed consent. All cases of AD were confirmed by a documented diagnosis in the Brigham and Women's Hospital medical record by a board-certified dermatologist and an ICD 9 diagnosis. Participants were excluded if they did not speak English, did not answer all questions on the questionnaire, or did not have both a confirmed medical record diagnosis and ICD 9 diagnosis. Demographic data (age and sex) were obtained for all participants through a medical record review.

Responses were collected from 121 participants. Thirteen responses did not meet the inclusion criteria and were not included for data analysis. Of the remaining 108 participants, 27 were classified as cases (AD group) and 81 as controls. Of the controls, 19 were seen for psoriasis, 12 for non-AD rashes, 12 for skin cancer (e.g., basal cell carcinoma, squamous cell carcinoma), 11 for acne, eight for warts or cysts, seven for nevi, six for disorders of pigmentation (e.g., vitiligo, acanthosis nigricans), two for pemphigus, two for scleroderma, one for hidradenitis suppurativa, and one for allergic reaction to antibiotics. Thirty of the 81 controls had previous diagnoses of some form of dermatitis, but none had a previous diagnosis of AD.

Statistical analysis

Sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) for each individual question were determined based on standard calculations, and 95% confidence intervals were constructed for all measures. A preliminary logistic regression analysis was conducted to assess the relative contribution of each question. For Qpic, a further hierarchical logistic regression analysis was conducted to assess the relative contribution of each question to Qpic, using IBM SPSS Statistics for Windows (Version 22.0; IBM Corporation, Armonk, NY, USA). A receiver operating characteristics curve was generated for Qpic, and the area under the curve was calculated using SAS software (SAS Institute Inc., Cary, NC, USA). Four scoring algorithms that combined one or more questions in the ADSEQ were created and tested. The questions

were chosen based on two considerations: their sensitivity and specificity percentages on individual analysis and their contribution towards explaining the variance of AD based on the logistic regression analysis (see the Results section for details). For algorithm 3 (itchy skin and the four questions comprising Qpic), which had the highest sensitivity (indicating lowest missing diagnoses), we calculated the Cronbach's alpha value using SPSS (SPSS Inc., Chicago, IL, USA) software.

Results

The sensitivity, specificity, PPV, and NPV for an AD diagnosis for each ADSEQ question were calculated (Table 1). Q2, 3, 12, and 13 were excluded because they were only applicable to AD cases. Of the remaining questions, Q7a (Does your skin itch frequently?) had the highest individual sensitivity (96.3%), while the four pictorial questions, collectively defined as Qpic (Q8–11: Have you had a similar rash to any of the following pictures?), had a combined sensitivity of 96.3%.

A preliminary logistic regression was conducted to assess the relative contribution of each question towards explaining the variance of AD. Four questions that made the most contribution were past diagnosis of AD by a healthcare professional (Q1), family history (Q5), itchy skin (Q7), and Qpic (Q8–11). As Qpic and Q7a had the highest sensitivities, and Qpic had a greater specificity, PPV, and NPV than Q7a, a hierarchical logistic regression was conducted to assess the relative contribution of each question to Qpic. Our results indicated that when all other predictor variables were added, Qpic was the biggest predictor of AD. Itchy skin also made a unique contribution to the prediction of AD even when all the other predictor variables were included in the model. Using Qpic as a continuous variable, the area under the receiver operating characteristic curve is high ($C = 0.88$ with $SE = 0.03$ and 95% CI from 0.82 to 0.95), suggesting that Qpic is a good diagnostic indicator by itself. Based on these results, four scoring algorithms were developed to assign a diagnosis of AD. Of these, scoring algorithm 3 had the highest sensitivity of 96.3% (95% CI: 89.2–100%) and a specificity of 84.0% (95% CI: 76.0–92.0%) (Table 2).

Finally, we checked the inter-item correlation between the five questions included in scoring algorithm 3 (e.g., itchy skin and the four questions comprising Qpic). Cronbach's alpha coefficient was 0.71, indicating acceptable internal consistency.

Discussion

Ascertainment of AD diagnosis is important for data analysis and result interpretation in large epidemiological

Table 1 Sensitivity, specificity, PPV, and NPV for each individual Atopic Dermatitis Screening and Evaluation Questionnaire

	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)
Q1: Ever been diagnosed by a doctor, nurse practitioner/physician's assistant, or dermatologist	92.6 (82.7, 100.0)	82.7 (74.5, 91.0)	64.1 (49.1, 79.2)	97.1 (97.1, 93.4)
Q4: Other atopic disease (asthma, seasonal allergies, food allergies)	63.0 (44.8, 81.2)	66.7 (56.4, 76.9)	38.6 (24.3, 53.0)	84.4 (75.5, 93.3)
Q5: Atopic family history (asthma, seasonal allergies, food allergies, atopic dermatitis)	88.9 (77.0, 100.0)	44.4 (33.6, 55.3)	34.8 (23.5, 46.0)	92.3 (83.9, 100.0)
Q6: Dry skin	81.5 (66.8, 96.1)	46.9 (36.1, 57.8)	33.9 (22.3, 45.4)	88.4 (78.8, 98.0)
Q7a: Itchy skin	96.3 (89.2, 100.0)	63.0 (52.5, 73.5)	46.4 (33.4, 59.5)	98.1 (94.3, 100.0)
Q7b + Q7c: Itch on average and itch at its worst combined >90/100	66.7 (48.9, 84.5)	85.2 (77.5, 92.9)	60.0 (42.5, 77.5)	88.5 (81.4, 95.6)
Q8: Rash on elbow folds, behind knees, on ankles similar to picture	77.8 (62.1, 93.5)	86.4 (79.0, 93.9)	65.6 (49.2, 82.1)	92.1 (86.0, 98.2)
Q9: Rash on hands similar to picture	40.7 (22.2, 59.3)	87.7 (80.5, 94.8)	52.4 (31.0, 73.7)	81.6 (73.5, 89.8)
Q10: Rash on head and neck similar to picture	44.4 (25.7, 63.2)	91.4 (85.2, 97.5)	63.2 (41.5, 84.9)	83.2 (75.4, 90.9)
Q11: Rash on feet similar to picture	25.9 (9.4, 42.5)	92.6 (86.9, 98.3)	53.9 (26.8, 81.0)	79.0 (70.8, 87.2)
Qpic (Q8 + Q9 + Q10 + Q11): Rash similar to any of the four pictures	96.3 (89.2, 100.0)	76.5 (67.3, 85.8)	57.8 (43.4, 72.2)	98.4 (95.3, 100.0)

NPV, negative predictive value; PPV, positive predictive value.

Qpic = Yes when Q8 or Q9 or Q10 or Q11 = Yes.

95% confidence interval in brackets for each value.

Table 2 Sensitivity, specificity, PPV, and NPV of Atopic Dermatitis Screening and Evaluation Questionnaire algorithms

	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)
Scoring algorithm 1: If Q1 = Yes and Qpic = Yes → AD	92.6 (75.7, 98.9)	86.4 (77.0, 93.0)	69.4 (51.9, 83.6)	97.2 (90.3, 99.6)
Scoring algorithm 2: If Qpic = Yes and Q5 = Yes → AD	85.2 (71.8, 98.6)	87.7 (80.5, 94.8)	69.7 (54.0, 85.4)	94.7 (89.6, 99.8)
Scoring algorithm 3: If Qpic = Yes and Q7a = Yes → AD	96.3 (89.2, 100.0)	84.0 (76.0, 92.0)	66.7 (51.9, 81.5)	98.6 (96.7, 100.0)
Scoring algorithm 4: If Qpic = Yes and Q7a = Yes and Q5 = Yes → AD	85.2 (66.3, 95.7)	92.6 (84.6, 97.2)	79.3 (60.3, 92.0)	94.9 (87.5, 98.6)

AD, atopic dermatitis; NPV, negative predictive value; PPV, positive predictive value.

95% confidence interval in brackets for each value.

studies. Here we present a simple, fast, and effective screening tool that can be used to validate a self-report of AD. Through pilot testing in an outpatient dermatology clinic, we have shown that participant responses to a combination of questions on the ADSEQ can be used to reliably ascertain a diagnosis of AD with high sensitivity and specificity.

An analysis of the sensitivity, specificity, PPV, and NPV of each of the individual questions on the ADSEQ revealed several interesting results. First, we found that the co-occurrence of asthma, seasonal allergies, and food allergies had a PPV for AD of 38.6% (95% CI: 24.3–53.0%) on the ADSEQ with a sensitivity of 63%. Interestingly, family history of atopic diseases had a similar PPV of 38.6% (95% CI: 23.5–46.0%) but a higher sensitivity of 88.9%. This is in keeping with the atopic triad, the link between the development of AD, asthma, and allergic rhinitis, and the results of previous studies reporting an asthma co-occurrence of 10–53% and an allergic rhinitis co-occurrence of 29–78% with AD.^{12–14} Furthermore, our analysis of the individual questions on the

ADSEQ also revealed that the presence of itchy skin (Q7a) has a higher sensitivity, specificity, PPV, and NPV for AD than the presence of dry skin (Q6), suggesting that the former is a better predictor of AD than the latter. Finally, while the four representative pictures of AD on different body locations (Q8–11) had relatively low individual sensitivity (77.8%, 40.7%, 44.4%, and 25.9%, respectively), they had very high sensitivity in aggregate as 96.3%, suggesting that grouping these pictures together can serve as a sensitive predictor of AD status.

The ADSEQ was developed as a self-diagnosis validation tool to be used in remote populations. As such, the ADSEQ is brief (13 questions), fast (completion time under 3 min), and can be easily disseminated to large populations both in the United States and worldwide. While the ADSEQ is not meant to replace an evaluation by a dermatologist in any way, the tool represents a validated and pilot-tested questionnaire that can be self-administered by patients in their own homes or used in conjunction with the dermatologic evaluation during the clinical encounter. The ADSEQ differs from previous AD

screening questionnaires in several important ways. Unlike the International Study of Asthma and Allergies in Childhood eczema questionnaire and the Centers for Disease Control AD screening questionnaire, the ADSEQ was not developed for a particular population in mind (e.g., children or hospital workers) but was conceptualized as a general tool for an adult population. In addition, the ADSEQ includes representative images of AD that may be more accessible to non-English speakers, improving its use in remote populations without access to healthcare providers. Finally, our pilot study demonstrated that the ADSEQ has a sensitivity of 85.2–96.3% and a specificity of 84.0–92.6% (the sensitivity score from the International Study of Asthma and Allergies in Childhood: 37.1%, specificity: 90.0%;¹⁵ Centers for Disease Control sensitivity: 60–88%, specificity: not reported),¹⁶ suggesting that it may be a more predictive diagnostic tool than existing AD screening questionnaires.

Our study is a pilot study, and the data used for the analyses were obtained from a relatively small sample of patients recruited from one tertiary care referral center in Boston. Therefore, a major limitation of this study is the generalizability of the ADSEQ to other populations. However, a combination of questions on AD diagnosis, images, and symptoms provides a reasonably reliable and sensitive method to validate AD self-reports. Another limitation of the study is the timing of the questionnaire. Owing to clinic flow, a small number of patients ($n < 5$) completed the questionnaire after being seen by a dermatologist, which may have introduced some bias to their responses if they were being seen for AD. While these patients were not coded separately and unfortunately cannot be distinguished from the patients who were seen before the clinic visit, the impact of any bias from this group on the results is probably small as the vast majority of patients were seen before the clinical visit. Important next steps will be to streamline the ADSEQ based on the results of our analysis (for example, removing some questions that were not used in our algorithms) and test the ADSEQ tool on a larger sample of patients whose data were not used in its development. Future research will focus on validating the performance of the ADSEQ on a much larger population of patients both locally and from across the USA.

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