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## **Eczema apps conformance with clinical guidelines: A systematic assessment of functions, tools and content**

Running title: Eczema apps conformance with clinical guidelines

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## KEY POINTS

### What's already known about this topic?

There is limited information about the quality of eczema self-management smartphone apps on the global market.

### What does this study add?

This systematic assessment evaluated all English, Chinese and Spanish language apps that support eczema self-management. The majority did not conform with information in guidelines and insufficiently support evidence-based self-management. The large variance in the quality of eczema apps highlights the need for mechanisms to ensure app quality and guide personalized app selection for patients, caregivers and doctors.

## TEXT

### Summary

**Background:** Eczema is a prevalent complex skin condition requiring active disease monitoring and personalized education. No studies have assessed the quality of apps aiming to support eczema self-management.

**Objectives:** To evaluate quality and comprehensiveness of English, Chinese and Spanish self-management eczema smartphone apps for patients and/or their caregivers.

**Methods:** A systematic assessment of eczema apps from July to November 2018. The assessment criteria were based on conformance with international eczema guidelines. Following domains were assessed: consistency and comprehensiveness of eczema specific educational information; quality and comprehensiveness of eczema specific tracking functions; compliance with health information best practice principles.

**Results:** 98 apps were assessed. 82 (84%) provided educational information, 38 (39%) tracking functions, and 13 (13%) both. 34% (28/82) of apps provided misleading information, particularly in aspects of treatment and disease progression of eczema. Only 15% (12/82) provided international guidelines supported information on pharmacological therapies and 16% (13/82) on non-pharmacological therapies. Among 38 apps with a tracking function, 82% (31/38) measured specific symptoms, disease severity or current skin condition and 89% (34/38) helped users to record medication usage including application of topicals. 34% (13/38) recorded environmental or dietary allergens. None of the included apps complied with all criteria for educational information, tracking functions or health information principles.

**Conclusions:** The eczema apps have not yet reached their potential. The large variance in quality of eczema apps highlights the need for quality assurance mechanisms for health apps and guidance for clinicians which would enable them to make personalized recommendations to patients and caregivers.

## Introduction

Eczema is the most common skin disease. One in five people are affected during their lifetime and recent data shows that its prevalence is still increasing, especially in low-income countries.<sup>1</sup> Eczema is a complex chronic disease which causes various distressing symptoms such as itch, sleep disturbance as well as changed skin appearance. It can greatly impact patients' mental and physical health;<sup>2</sup> The psychosocial impact and stress on caregivers of individuals with eczema have been found to be greater than for patients with insulin-dependent diabetes.<sup>3</sup> Self-management plays a pivotal role in improving the quality of life among eczema patients, however evidence and practice show there is low adherence to recommended prevention and management measures including use of topical and oral medication.<sup>4</sup>

Understanding of the disease increases patient satisfaction with the treatment and results in improved outcomes and adherence.<sup>5</sup> Well-educated patients have significant improvements in their disease severity scores compared with controls.<sup>6</sup> For timely recognition of flares and informed treatment decisions during clinic visits, guidelines advocate tracking of the disease by a) monitoring possible triggers (e.g. allergens), b) recording disease severity including specifically symptoms and signs c) response to therapy.<sup>7</sup> There is an increasing need for various monitoring means to support patients, their caregivers and healthcare professionals in managing the disease.

Smartphone apps can increase patients' and carers' knowledge of the disease, support self-management and empowerment by, for example, giving patients insight into their health condition, enabling them to make informed choices and engaging them in self-care activities and potentially diminishing the need for

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face to face contact with their health care professionals.<sup>8</sup> Dermatological conditions are deemed suitable for smartphone-supported management, as clinical diagnosis and assessment of severity partly rely on visualization. This is reflected by the number of dermatology-related mobile apps which have more than doubled in the past years.<sup>9</sup> Studies have, however, found diagnostic inaccuracy of smartphone applications and several other reports have also suggested that the app marketplace has much to improve.<sup>10</sup> For apps to be used and recommended to patients and their healthcare providers, accuracy and reliability are essential. Incorrect information and recommendations, in addition to privacy issues, are some of the key challenges of current apps.<sup>11</sup>

Research has not yet focused on eczema smartphone apps. Given the hypothetical benefits and challenges, quality and comprehensiveness of available eczema self-management apps should be evaluated to guide clinicians and patients in recommending and using the most appropriate apps. To assess the global marketplace, apps available in the most spoken languages (English, Chinese, and Spanish) will provide a comprehensive overview covering a population of nearly two billion people.<sup>12</sup> This study systematically assesses the self-management functionalities of all available apps accessible to English, Chinese and Spanish speaking patients or caregivers of eczema patients.

## Materials and methods

### *Search strategy*

This cross-sectional study reviewed all eczema self-management apps for patients/caregivers available from July to November 2018. The app selection and identification were conducted using a systematic approach to minimize bias. Apps were identified using specific search terms and subsequently reviewed for suitability based on app store descriptions. Suitable apps were downloaded for testing against pre-defined criteria. Apps that appeared across multiple platforms were assessed separately. Apps with in-app purchases were assessed with and without the full purchase of additional features/functionalities. If apps were translated into another language, apps were also assessed individually.

English, Chinese and Spanish language smartphone apps were searched for using 42matters, an app search engine that retrieves apps from most widely used smartphone stores (Google Play store and Apple App store iOS) which covers apps from 55 countries in both above-mentioned operating systems.<sup>13</sup> As Chinese apps are not available in Google Play in mainland China, Chinese Android apps were searched through the platforms used by more than 95% of the users in China<sup>14</sup>: 'Tencent MyApp', '360 Mobile Assistant', 'Baidu Mobile Assistant', 'Huawei App Market', 'Oppo Software Store', 'MIUI App Store', 'VIVO App store', 'Sogou

Mobile Assistant', 'PP Assistant' and 'Wandoujia' platform. Search terms "atopic dermatitis, "eczema", "dermatitis", "rash", "dermatology", "skin disease" and Chinese and Spanish translations of these terms were used. English search terms: 1) eczema, 2) atopic dermatitis or dermatitis, 3) dermatology or derma\*, 4) skin disease or skin; Chinese search terms: 1) 湿疹, 2) 红疹 or 疹, 3) 皮炎, 4) 藓, 5) 皮肤病; Spanish search terms: 1) dermatitis atópica, 2) eccema or eccemas atópicos, 3) dermatitis, 4) rash or rash cutáneo or erupción cutánea, 5) dermatología, 6) enfermedad de la piel or enfermedades de la piel or enfermedad cutánea or enfermedad dermatológica or dermatopatía or dermatopatías" or dermatopatías eccematosas. To assure the terms were conceptually equivalent to the English terms forward- and back-translations were used.

If apps were downloadable and accessible, they were assessed for inclusion using predetermined inclusion and exclusion criteria.

Inclusion criteria:

- 1) Smartphone or tablet app available on Google Play store, Apple App (iOS) store and Chinese Android App stores
- 2) Dermatology related app with an eczema section
- 3) English/Chinese/Spanish language
- 4) Free or paid
- 5) Content or tools addressing one or more aspects of eczema diagnosis, management, monitoring or support as either the sole function or in a way that eczema related elements can be isolated from the rest of the content
- 6) Target patients with eczema or caregivers of children with eczema

Exclusion criteria:

- 1) Targeted solely at healthcare providers
- 2) App explicitly disclaims that it is intended for health-related purposes
- 3) App has no other function apart from teleconsultation for eczema
- 4) App only includes alternative medicine/homoeopathy/home remedies
- 5) App cannot be used due to technical problems after two attempts
- 6) Outdated – incompatible with current operating systems (iOS 11.4.2 and Android 8.0.0)

### **Assessment**

Eczema-specific app assessment criteria were developed to review the range of features and functions that support management of eczema and the extent to which the apps are consistent with international eczema guidelines. To establish the criteria American Academy of Dermatology Guideline,<sup>15,16</sup> The National Institute

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for Health and Care Excellence (NICE) Guideline (2007),<sup>17</sup> Guidelines for the Management of Atopic Dermatitis in Singapore,<sup>18</sup> Guidelines for the Management of Atopic Dermatitis in China (湿疹诊疗指南) and the Argentinean Atopic Dermatitis National Consensus (Consenso Nacional de Dermatitis Atópica 2013) were used, subsequently they were reviewed by co-authors who are all physicians and two experienced dermatologists. Self-management was divided into the apps' tracking and educational (information-providing) function. In terms of app functionality, Health on the Net (HONcode) principles were adapted to assess the reliability of information based on citations, justifications of claims and authority of information, as well as adherence to ethical standards of transparency, privacy and advertising policies.<sup>11,19</sup> An example of two criteria and their assessment is listed in Table 1 (the full assessment criteria can be found in Supplement 1).

App assessment was performed on an iPhone 7 (iOS 11.4.1) and a Sony XPERIA XZs (Android 8.0.0). To establish standardization of interpretation and application of the assessment criteria, 24% of English and Chinese apps were first assessed individually by one pair of assessors (PC and ZH), and differences were discussed and resolved through consensus. Assessment of remaining apps was performed by reviewers in pair (PC and ZH both speaking English and Chinese, reviewed English and Chinese apps; AP and LM both speaking English and Spanish, reviewed Spanish apps) independently assessing each app in a random order. Discrepancies were resolved through discussion with a third independent reviewer (XM and LVG) in the team.

### ***Data analysis***

Cohen's Kappa was used to calculate the inter-rater agreement between two reviewers at initial screening and assessment process. An agreement between 60-80% represents a reasonably good agreement between the reviewers. Apps were profiled according to types, functions, and quality of included apps using descriptive statistics (frequencies and percentages). No further statistical analysis was deemed relevant. The units of analysis are the platform-specific app and target user group. Subgroup analysis for eczema-specific assessment and HONcode principles was done using Stata software version 14.2 (StataCorp, College Station, TX, USA).

## **Results**

### ***App selection***

The flowchart of app selection is shown in Figure 1. The initial search yielded 1522 potential apps in English (938 Android apps and 584 IOS apps), 255 Chinese apps in IOS (Android Chinese apps were assessed

manually because Chinese Android apps are not available in Google Play in mainland China), and 676 in Spanish (422 Android apps and 254 iOS apps). Two-hundred and thirty-six apps were downloaded for full assessment after the primary screening (136 English apps, 81 in Android and 55 in IOS; 21 Chinese IOS apps and 79 Spanish apps, 48 in Android and 31 in iOS). After downloading, 98 apps were included for final assessment (67 English, 22 Chinese, 9 Spanish). Eight apps (8/98, 8%) present in both iOS and Android were assessed as separate apps, four apps (4/98, 4%) were assessed twice (free and paid). There were four (4/98, 4%) apps translated from English to Spanish. Thirty-one per cent (28/89) of English and Chinese apps were assessed by two assessors with mean Cohen's kappa of inter-rater reliability of 0.796. Forty-four per cent (4/9) of the Spanish apps were assessed by both assessors, the Cohen's kappa for the Spanish apps was 0.650. All apps assessed in pairs were discussed after the initial assessment, where after consensus was reached. The list of assessed apps is available from the authors.

### ***App characteristics***

Table 2 presents basic app characteristics. Amongst the 98 assessed apps, 84% (82/98) provided educational information, 39% (38/98) had disease tracking functions, and 13% (13/98) did both. Most apps targeted adult users (76/98, 78%), followed by caregivers (19/98, 19%) and children (below age 13) (3/98, 3%). Fifteen per cent (15/98) required payment (or contained an in-app purchased domain) with a median cost of \$2.99 USD (range \$0.99-\$8.68). Technical errors (such as crashing, freezing or getting stuck during use) were found in three of the assessed apps (3/98, 3%). Eight apps (8/98, 8%) offered games and three apps (3/98, 3%) provided reward programs. Thirteen apps (13/98, 13%) allowed users to share the record to social media. Seventeen apps (17/98, 19%) protected user's privacy by requiring a password to login the app. Twelve apps offered (12/98, 12%) direct access to a healthcare professional by, for example, a video or audio consultation. Eight apps (8/98, 8%) helped users connect to an eczema support group.

### ***Eczema specific educational information criteria***

Table 3 shows the assessed content and function for the apps providing educational information (n=82), none of the apps provided all listed information. However, more than two-thirds (64/82, 78%) provided information on pharmacological management. Sixty-five (65/82, 79%) provided instruction on application of topical creams such as calcineurin inhibitors and corticosteroids, and 39 (39/82, 48%) provided information on side-effects of medication. Only 15% (12/82) provided a valid source for pharmacological information (sources were considered valid if they were reported by certified doctors, cited peer-reviewed papers, international guidelines, or referred to government websites or websites with another validated source). Sixty-four (64/82, 78%) offered education on non-pharmacological therapies such as moisturizer application and bath habits, 13 of these (13/82, 16%) provided the valid source for non-pharmacological therapies. The majority (60/82, 73%) provided information on environmental allergens, and fifteen (15/82, 18%) provided

food allergy related information. In terms of customization of eczema management, twenty apps (20/82, 24%) mentioned the role of an action plan and the prioritization of management goals.

Content in more than one-third (28/82, 34%) of apps providing educational information was not in agreement with international guidelines. The inconsistency was largely related to use of topical steroids. Ten apps (10/82, 12%) discouraged the long-term use of topical steroids while several guidelines recommend them as maintenance medication in moderate to severe disease.<sup>7,15-17</sup> Twelve per cent (10/82) advised on home remedies without disclaiming these are non-evidence-based therapies (e.g. vitamin supplements and probiotics). Inaccurate information on the pathophysiology and mechanisms of AD was found in 13% (11/82), focusing only on certain contributing factors such as allergies and not mentioning the multifactorial nature of the disease. Nine out of 82 apps (9/82, 11%) failed to mention mainstay therapies such as the use of emollients and moisturizers. Other inconsistencies found during the assessment were inappropriate recommendations on commercial bath additives (1/81, 1%), home dust mite covers and massages (1/81, 1%) as well as misguidance on dietary changes (1/81, 1%) and shower and bath behaviour (1/81, 1%).

#### ***Eczema specific tracking function criteria***

Table 4 demonstrates the tracking functions available in the apps (n=38). None of the apps contains all the features listed in Table 4. Thirty-one out of 38 apps (82%) provided a function to track disease status of which 12 (12/38, 32%) used a validated scoring system such as POEM, SCORAD, and PEST.<sup>15,20,21</sup> Fourteen (14/38, 37%) allowed users to set reminders to record the status of the disease. Thirteen (13/38, 34%) checked the users' psychological status regularly for example by the level of sleep disturbance, stress, and mood, with advice such as how to manage stress or seek counselling. Most (34/38, 89%) apps provided a disease management tracking function; thirteen (13/38, 34%) helped users record oral medicine intake (e.g. cyclosporine, azathioprine, methotrexate), sixteen (n=16/38, 42%) provided a topical application record function for users. Less than half (17/38, 45%) allowed users to set reminders for treatment management and only four apps (4/38, 11%) provided advice if the skin condition worsened. Thirteen out of 38 apps (34%) provided tracking functions on environmental factors by real-time environmental condition tracking (e.g. pollens, humidity, temperature through passive data collection) and recording potential environmental triggers. Eleven apps (11/38, 29%) had a food diary function for patients and caregivers on documenting any foods that may trigger eczema. None of the apps allowed users to set goals based on their own needs.



### **Health on Net (HON) code principles**

Figure 2 displays the percentage of apps which complied with the Health on the Net principles.<sup>19</sup> None of the included apps met the terms of all eight principles. Most of the apps (78/98, 80%) had contactable developers (transparency principle) and provided a financial disclosure (69/98, 70%). Few apps (15/98, 15%) indicated the qualifications of the specific individuals who developed the app or contributed to the information provided (authoritative principle). Thirty-one percent of the apps (30/98) indicated a privacy and/or confidentiality clause in the app. Additionally, we assessed whether the app treated the data gathered from children separately as children may need to use the app under their caregiver's supervision. Most of the apps did not differentiate between user profiles. Some apps designed for caregivers mentioned that those below 18 must use the app under parental supervision.<sup>22,23</sup> Another directed users to pass the phone to parents to enter personal information.<sup>24</sup>

### **Discussion**

We systematically assessed all available eczema self-management apps for patients and their caregivers in the three most widely spoken languages. Available eczema apps (n=98) most common function is information provision (n=82, 84%), followed by disease tracking (n=38, 39%). Evaluated apps had diverse functionalities with varying quality. Most apps failed to cite their source of educational information, and even apps with cited claims or information provided by qualified doctors contained content inconsistent with guidelines. This is concerning, particularly with regards to steroid use where balanced information about appropriate use, dosing, and side effects should be sufficiently explained, as concerns about steroid side-effects are a common reason for their underuse and a major barrier to appropriate eczema management.<sup>25,26</sup>

Frequent tracking is the cornerstone of effective eczema self-management.<sup>7,17</sup> Therapy is needed on a daily basis and patients with more severe eczema require intensive, individualized management and monitoring. Currently, only 38 apps (38/98, 39%) provide disease tracking functions and only one in eight (12/98, 12%) allow users to directly access a healthcare provider via a fee-based teleconsultation (we did not assess the apps which were merely designed for teleconsultation). Another gap in apps functionality was incomprehensive tracking of eczema triggers such as possible allergens in food and environment, which could help prevent flares.<sup>27</sup> A clear description of the app's functionalities when downloading the app could align patients' and healthcare professionals' needs when a patient, for example, is just looking for allergen tracking some of the apps might be better than others.

Information on psychological impacts and interventions was not provided in the majority (46/82, 56%) of apps. This is concerning since eczema has serious psychological implications and is an independent risk factor for psychiatric conditions like affective and stress-related disorders.<sup>28,29</sup> Moreover, stress may also be an aggravating factor,<sup>30</sup> perpetuating a vicious cycle. Nevertheless, recording physical and mental health information is sensitive<sup>31</sup> and poor security and transparency may impede a user's willingness to input such information.<sup>32</sup> We found 35% of the apps failed to provide a proper privacy policy (Figure 2).

Inconsistency of provided information was also identified in insulin calculation,<sup>33</sup> smoking cessation and asthma self-management apps in previous studies.<sup>33-35</sup> Likewise, in other dermatology apps, concerns of efficacy and accuracy of diagnostic tools in skin cancer screening and early melanoma detection have been expressed.<sup>36,37</sup> Investigated smartphone apps detecting melanoma lesions have shown low sensitivity with seemingly inaccurate assessment potentially resulting in giving patients a false reassurance.<sup>38,39</sup> Moreover, established quality standards or regulatory oversight of mobile medical apps mainly focus on apps connected to medical devices. The exclusive focus on these misses opportunity for positive impact and impedes safeguards of minimizing harm for the users of the majority of medical apps which are not connected to devices. Consulting incorrect or incomprehensive app resources, for information about disease conditions instead of seeking the care of healthcare professionals could pose a risk on patients and their caregivers.<sup>38</sup>

This study has several merits. First, with covering all apps available in the three worldwide most widely spoken languages, we are the first to provide a comprehensive overview of eczema apps. Apps included in this review cover more than 1.8 billion of the world's population.<sup>12</sup> Our results are a reference to patients and health professionals who aim to recommend to their patients eczema self-management apps. Secondly, guideline-derived assessment criteria provide a validated rational basis from a clinical and technical point of view. Thirdly, this study adopted a systematic assessment methodology using our team's experience, which reduces the possible bias compared to other assessment and reviews.<sup>33-35</sup>

The scope of the study is however limited as assessment was not able to cover the entire spectrum of apps related to eczema management due to overlapping functionalities hidden within other apps. For example, general health-tracking apps may be used to monitor eczema, and specific information may be found in general dermatology apps. This limitation should not affect the purpose of this review since our search specifically focused on eczema apps to support self-management. Teleconsultation apps, which constituted 21.0% of dermatology apps available in 2017, were also excluded.<sup>40</sup> Future studies could investigate the quality of teleconsultation and general health apps in supporting eczema self-management. Other important areas that are not reported in this study are the usability and the appropriateness of in-app

adverts. However, there are still limited validated measures to reliably assess usability for health apps from different users' perspectives. While it is ideal to have multiple functions built into an app, the ease of use of an app will determine its adoption by patients and its resultant benefits. As such, apps must be customized taking into consideration a patient's lifestyle and level of comprehension such that it integrates into a patient's routine way of life. A final caveat is the lack of evaluation if information was understandable for the specific target groups.

Even though dermatology-related apps have been developed at unprecedented speed and volume, systematic assessment of their safety and efficacy is lagging behind.<sup>40</sup> Individuals with eczema could benefit from the promotion and dissemination of healthcare apps. However, the under-investigated reliability and accuracy of these tools obscure their efficiency or even bring unpredictable risk to the targeted users. We found that patients should use the available eczema self-management apps with caution. Meanwhile, healthcare professionals should be aware of the issues, direct patients to selected apps with comprehensive tracking functions and validated information and could alternatively consider advocating the use of other reliable information resources such as accredited webpages or disease-specific educational leaflets.<sup>41,42</sup> Also, regulation, certification or similar quality assurance mechanisms of medical smartphone apps should adequately keep pace. Policymakers need to review the developer's qualifications before any healthcare related apps are offered to the patients and the public and increase the threshold for entering the market by setting evidence-based app quality controls and implementing user-friendly accreditation programs.<sup>11</sup> During the development process, innovative models such as co-design could ensure all stakeholders are consulted frequently to assure the accuracy, efficacy, and user-friendliness of apps.

The assessed eczema self-management apps had shortcomings, however certain apps did provide appropriate functions with accurate information and comprehensive tracking of eczema-related factors. The large variance in assessed quality of available eczema apps underlines the need for the published recommendation of apps or guides to aid clinicians in advocating appropriate apps for eczema patients and caregivers. With room for further development of quality, the field of mobile health has great potential to better patient care and self-management of eczema, address major unmet needs, and open new modalities to supplement traditional models of care, provided that appropriate measures are taken to improve the quality standards.

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## FIGURE LEGENDS

### Figure 1. Flowchart of app selection process

\*Not included are the manually searched Chinese Android apps on the platforms<sup>25</sup>, these were not retrievable through a search engine and therefore primary screening was not undertaken for these apps

### Figure 2. HONcode principles

Advertising policy - App distinguishes advertorials from content; Financial disclosure - App indicates funding sources; Transparency - App developers are contactable (by e-mail); Justifiability - App backs up claims relating to the benefits and performance by evidence; Attribution - App cited information sources; Privacy - App has a privacy and/or confidentiality clause; Complementarity - App has a disclaimer stating information provided and/or app function do not replace healthcare providers advice; Authoritative - App indicates the qualifications of specific individuals who developed the app or contributed to the information provided.

TABLES

**Table 1. Example of app assessment criteria** (Please refer to supplement 1 to access the full criteria)

<b>Field</b>	<b>Description</b>	<b>Justification/Evidence</b>	<b>Options</b>
Treatment management	Does the app provide any information on disease management?	<p>Patients should be given instructions on the needs to safely and effectively self-manage their medicines. [NICE Clinical Guideline 76 (CG76)<sup>43</sup>]</p> <p>Healthcare professionals should spend time educating children with atopic eczema and their parents or carers about atopic eczema and its treatment. They should provide information in verbal and written forms, with practical demonstrations, and should cover:</p> <ul style="list-style-type: none"> <li>- How much of the treatments to use</li> <li>- How often to apply treatments</li> <li>- When and how to step treatment up or down</li> <li>- How to treat infected atopic eczema.</li> </ul> <p>[NICE Clinical Guideline 57 (CG57)<sup>17</sup>]</p>	<p>Yes/No</p> <p>◆ Yes-if the app contains any information with eczema management in any form (video/text/game/quiz).</p> <p><i>Example. An app<sup>44</sup> has games to teach users to apply moisturizer.</i></p> <p>◆ No-if the app does not <a href="#">contain-provide any of the</a> above information.</p>
Psychological factors	Does the app provide any information on psychological management?	<p>During an assessment of psychological and psychosocial wellbeing and quality of life, healthcare professionals should take into account the impact of atopic eczema on parents or carers as well as the child and provide appropriate advice and support. [NICE Clinical Guideline 57 (CG57)<sup>17</sup>]</p>	<p>Yes/No</p> <p>◆ Yes-if the app contains any information with eczema psychological management in any form (video/text/game/quiz)</p> <p><i>Example. An app<sup>45</sup> asks users to assess their mood on daily basis.</i></p> <p>◆ No-if the app does not contain above information.</p>



**Table 2. App characteristics**

Characteristics	Description	Total, n (%) 98 (100)	App platform, n (%)	
			Android 62 (63)	IOS 36 (37)
<b>App language</b>	Primary language of the app			
English		67 (68)	45 (73)	22 (61)
Chinese		22 (22)	11 (18)	11 (28)
Spanish		9 (9)	6 (10)	3 (8)
<b>Governmental bodies partnership during the app development process</b>	Is the app created/commissioned/partnered by any governmental bodies / government-affiliated companies, hospitals or universities?	18 (18)	9 (15)	9 (25)
<b>Cost</b>	Cost to download the app			
Free		83 (85)	56 (90)	27 (75)
Paid		15 (15)	6 (10)	9 (25)
<b>Location restriction</b>	Is this app limited to certain locations/countries/regions?			
Only US		5 (5)	2 (3)	3 (8)
Only China		8 (8)	7 (11)	1 (28)
Only India		1 (1)	1 (2)	0 (0)
No restriction		84 (86)	52 (84)	32 (89)
<b>Target users n, %</b>	What is the target user of the app?			
Children (age below 13)		3 (31)	1 (2)	2 (6)
Caregivers		19 (19)	11 (18)	8 (22)
Adults (age 13 and above)		76 (78)	48 (77)	28 (78)
<b>Technical errors n, %</b>	Does the app get stuck, crash or frozen more than once when using	3 (31)	1 (2)	2 (56)
<b>Education features n, %</b>	Does the app have any function related to providing information on disease pathophysiology / treatment / psychological factors / environmental factors?	82 (84)	55 (89)	27 (75)
<b>Tracking features n, %</b>	Does the app have any function related to tracking of disease / treatment / QOL / environmental factors?	38 (39)	19 (31)	19 (53)

Supporting attributes n, %				
Rewards	App provides a reward programme for users	3 (31)	1 (2)	2 (6)
Games	Does the app contain any games?	8 (8)	4 (6)	4 (11)
Password protected	App requires a personal login and password	17 (17)	8 (13)	9 (25)
Share to social media	Does the app allow recorded data of the patient to be shared on social media (e.g. Facebook/twitter?)	13 (13)	8 (13)	5 (14)
Data export	Does the app allow data to be exported (e.g. PDF/Excel, email, cloud, etc.)?	21 (21)	13 (21)	8 (22)
Access to healthcare professionals	Does the app include a health professional who is accessible to the user (without users inputting any health provider/health professional information)?	12 (12)	6 (10)	6 (17)
Support group	Can the app connect the user to a community/support group of other users/caregivers with eczema?	8 (8)	5 (81)	3 (8)
Advertisement	Does adverts interfere with the functioning of the app (if any?). Answer "Yes" if you feel bothered by the adverts, answer "No" if there are no adverts.	28 (29)	22 (35)	6 (17)

**Table 3. Educational information assessment criteria (n=82)**

Assessment criteria	Total n (%) 98 (100)	Targeted users n (%)		
		Children 3 (3)	Caregivers 19 (19)	Adult 76 (78)
<b>Information on disease mechanism and course</b>	64 (65)	2 (66)	16 (84)	46 (61)
<b>Information on symptoms</b>	68 (96)	3 (100)	19 (100)	46 (61)
<b>Information on pharmacological therapies</b>	65 (79)	1 (33)	15 (79)	49 (63)
▪ Topical application	65 (79)	1 (33)	15 (79)	49 (64)
▪ Side-effects	39 (40)	1 (33)	11 (58)	27 (36)

Provided valid source of pharmacological information	12 (12)	0 (0)	9 (47)	3 (4)
<i>Certified doctors</i>	7 (7)	0 (0)	7 (14)	0 (0)
<i>Peer reviewed papers and international guidelines</i>	4 (4)	0 (0)	1 (5)	3 (4)
<i>Authorised online sites (governmental support websites, evidence-based websites, etc. )</i>	1 (1)	0 (0)	1 (5)	0 (0)
<b>Information on non-pharmacological therapies</b>	64 (65)	3 (100)	16 (84)	45 (59)
▪ Bath practice	60 (61)	3 (100)	14 (74)	43 (57)
▪ Moisturizer application	49 (50)	2 (66)	14 (74)	33 (43)
▪ Wet wrap	20 (20)	1 (33)	5 (26)	14 (18)
▪ Using non-soap cleansers, bath additives, acidic spring water	44 (45)	2 (66)	12 (63)	30 (39)
▪ Side-effects	6 (6)	0 (0)	4 (21)	2 (3)
Provided valid source of non-pharmacological information	13 (13)	1 (33)	8 (41)	4 (5)
<i>Certified doctors</i>	6 (6)	0 (0)	6 (32)	0 (0)
<i>Peer reviewed papers and international guidelines</i>	4 (4)	0 (0)	1 (5)	3 (4)
<i>Authorised online sites</i>	3 (3)	1 (33)	1 (5)	1 (1)
<b>Information on the goals of management</b>	20 (20)	0 (0)	7 (37)	13 (17)
<b>Information on psychological /QoL</b>	36 (37)	1 (33)	8 (42)	27 (36)
<b>Information on food allergy</b>	15 (15)	1 (33)	2 (11)	12 (16)
<b>Information on aeroallergens</b>	60 (61)	1 (33)	16 (84)	4 (5)
<b>App provides all above information</b>	0 (0)	0 (0)	0 (0)	0 (0)

**Table 4. Tracking function assessment criteria (n=38)**

Assessment criteria (Does the app allow users)	Total (n=98) N (%)	Targeted users		
		Children 3 (3)	Caregivers 19 (19)	Adult 76 (78)
<b>Track disease status</b>	31 (32)	1 (33)	0 (0)	30 (39)
▪ Record current disease status	27 (28)	1 (33)	0 (0)	26 (34)
▪ Monitor disease based on recommended validated scoring systems (SCORAD, EASI, POEM)	12 (12)	0 (0)	0 (0)	12 (16)
▪ Set reminders to record eczema status	14 (14)	0 (0)	0 (0)	14 (18)
▪ Diagnostic functions	5 (5)	0 (0)	1 (5)	4 (5)
▪ Track of psychological factors	13 (13)	0 (0)	0 (0)	13 (17)
<b>Track disease management</b>	34 (35)	1 (33)	1 (5)	32 (42)
▪ Record oral medicine intake (e.g. Cyclosporine, azathioprine, methotrexate, etc.)	13 (13)	0 (0)	0 (0)	13 (17)
▪ Record topical application (e.g. topical calcineurin inhibitors, topical corticosteroids etc.)	16 (16)	0 (0)	0 (0)	16 (21)
▪ Key in frequency and dose for each medication (oral medicine, topicals)	13 (31)	0 (0)	0 (0)	13 (17)
▪ Record non-pharmacologic treatment management (moisturizers application, bath practice, wet-wrap etc.)	19 (19)	1 (33)	0 (0)	18 (24)
▪ Key in frequency and notes for non-pharmacologic treatments	14 (14)	1 (33)	0 (0)	13 (17)
▪ Set reminders for treatment management	17 (17)	1 (33)	0 (0)	16 (21)
▪ Provide information on step-up or step-down treatment	1 (1)	0 (0)	0 (0)	1 (1)
▪ Provide advice if skin condition becomes worse	4 (4)	0 (0)	0 (0)	4 (5)
▪ Set specific goals of management	2 (2)	0 (0)	0 (0)	2 (3)
<b>Track trigger factors</b>	13 (13)	0 (0)	0 (0)	13 (17)

▪ Provide real-time environmental conditions (e.g. Pollens, humidity, temperature, etc.)	5 (51)	0 (0)	0 (0)	5 (7)
▪ Record environmental triggers of eczema	11 (11)	0 (0)	0 (0)	11 (13)
▪ Contains a food diary	11 (11)	0 (0)	0 (0)	11 (13)
<b>App has all above features</b>	0 (0)	0 (0)	0 (0)	0 (0)



