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BRIEF REPORT

Qualitative Assessment of Adult Patients' Perception of Atopic Dermatitis Using Natural Language Processing Analysis in a Cross-Sectional Study

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ABSTRACT

Introduction: Atopic dermatitis (AD) is an incurable, inflammatory skin disease characterized by skin barrier disruption and immune dysregulation. Although AD is considered a childhood disease,

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adult onset is possible, presenting with daily sleep disturbance and functional impairment associated with itch, neuropsychiatric issues (anxiety and depression), and reduced health-related quality of life. Although such aspects of adult AD disease burden have been measured through standardized assessments and based on population-level data, the understanding of the disease experienced at the patient level remains poor. This text-mining study assessed the impact of AD on the lives of adult patients as described from an experiential perspective.

Methods: Natural language processing (NLP) was applied to qualitative patient response data from two large-scale international cross-sectional surveys conducted in the USA and countries outside of the USA (non-USA; Canada, France, Germany, Italy, Spain, and the UK). Descriptive analysis was conducted on patient responses to an open-ended question on how they felt about their AD and how the disease affected their life. Character length, word count, and stop word (common words) count were evaluated; centrality analysis identified concepts that were most strongly interlinked.

Results: Patients with AD in all countries were most frequently impacted by itch, pain, and embarrassment across all levels of disease severity. Patients with moderate-to-severe AD were more likely than patients with mild AD to describe sleep disturbances, fatigue, and feelings of depression, anxiety, and a lack of hope that were directly associated with AD. Centrality analysis revealed sleep disturbance was strongly

linked with itch. Collectively, these concepts revealed that patients with AD are impacted by both physical and emotional burdens that are intricately connected.

Conclusions: Qualitative data from NLP, being more patient-centric than data from clinical standardized measures, provide a more comprehensive view of the burden of AD to inform disease management.

Keywords: Atopic dermatitis; Natural language processing; Patient perception; Qualitative; Text-mining

Key Summary Points

Why carry out this study?

Atopic dermatitis (AD) is a chronic, relapsing, inflammatory skin disease characterized by itch, sleep disturbance, functional impairment, reduced health-related quality of life, depression and anxiety, systemic immune abnormalities, and impairments to work and school productivity

While the current understanding on the burden of AD has only been quantitatively characterized on the basis of clinical, mechanistic, and patient-reported outcome measures in trial and real-world settings, the full understanding of the impact experienced at the patient level is limited and would provide a more comprehensive view of the burden of AD to inform disease management

What was learned from the study?

Through the approach of natural language processing uncovering word patterns and important trends of experiences, the impact of AD on patients' lives as per their personal experience and choice of words was identified; interviewed patients from the USA, Canada, France, Germany, Italy, Spain, and the UK described not only a physical burden but also a substantial emotional burden due to their AD

Patients were most frequently impacted by itch, pain, and embarrassment across all levels of disease severity. Patients with moderate-to-severe AD were more likely than patients with mild AD to describe sleep disturbances, fatigue, and feelings of depression, anxiety, and a lack of hope that were directly associated with AD

INTRODUCTION

Atopic dermatitis (AD) is a chronic, relapsing, inflammatory skin disease characterized by intense itch, disruption of the skin barrier, and upregulation of type 2 immune responses [1]. AD most often presents in early childhood but can continue throughout, or first appear in adulthood, with an estimated adult prevalence of 2–10% across the USA and Europe [2, 3].

The burden of AD has been quantitatively characterized on the basis of clinical, mechanistic, and patient-reported outcome measures in trial and real-world settings. Manifestations of burden, such as itch, sleep disturbance, functional impairment, reduced health-related quality of life, depression and anxiety [4], systemic immune abnormalities [5–7], and impairments to work and school productivity, have all been reported with high prevalence [8]. However, these assessments only capture AD burden at the population level and, as such, the full understanding of the impacts experienced at the patient level is limited. Qualitative data may facilitate our understanding of the totality of the patient experience [9], providing important patterns and themes of AD from an individual patient perspective.

One approach to evaluating qualitative data is through using natural language processing (NLP) (Table 1), an innovative method to analyze text to derive implicit knowledge to inform the research objective. The approach has been applied in healthcare research, from biomedicine [10] uncovering valuable information on prostate cancer biomarkers [11] to psychiatry

Table 1 Terminology explained

| Terminology | Definition |
|-----------------------------|---|
| Natural language processing | The application of computational techniques to the analysis and synthesis of natural language and speech |
| Text-mining analysis | The process of exploring and analyzing large amounts of unstructured text data aided by software to identify concepts, patterns, topics, and keywords |

[12, 13] exploring patient perceptions on antidepressant withdrawal [13]. To our knowledge, the use of NLP to assess the patient experience in AD is limited. This study assessed the impact of AD on the lives of adult patients with AD through NLP.

METHODS

NLP analysis was conducted on patient responses to an open-ended question that was included in two multinational surveys on the burden of AD.

Population

Patients in the USA (at least 18 years of age) were selected from electronic medical records from six geographically diverse academic medical centers. Participants were included if they were diagnosed with AD (International Classification of Diseases, Ninth Revision, Clinical Modification [ICD-9-CM] 691.8 or 692.9) by a physician and had at least one visit for AD between January 1, 2013 and December 31, 2014.

Outside of the USA (non-USA), patients (18–65 years of age) from Canada, France, Germany, Italy, Spain, and the UK were selected if they had not participated in a randomized controlled trial for AD treatment in the past 12 months. Participants were included if they

were diagnosed with AD by a dermatologist (all countries), general practitioner (France and the UK), or allergist (France and Canada), and had at least one visit for AD between May 15, 2016 and November 21, 2017.

All patients provided informed consent and were stratified according to disease severity (mild or moderate-to-severe AD) based on the Investigator's Global Assessment (IGA) scale. Data were collected in accordance with ethical codes of the British Healthcare Business Intelligence Association, European Society for Opinion and Marketing Research (ESOMAR) and European Pharmaceutical Market Research Association (EphMRA), and was compliant with the US Health Insurance Portability and Accountability Act (HIPAA) of 1996. The study was approved at country level by the appropriate ethics committees (Canada: Research Review Board INC [07 June 2016] and Health Research Ethics Board of Alberta [04 January 2017]; France: Advisory Committee on Information Processing in Material Research in the Field of Health [12 July 2016] and National Commission for Computing and Liberties [26 October 2016]; Germany: Medizinische Hochschule Hannover [6 June 2016]; Spain: Hospital de la Santa Creu I Sant Pau [8 June 2016]; UK: Research Ethics Committee [29 September 2016] and Health Research Authority [9 December 2016]).

Data Collection

Qualitative data were derived from the international, cross-sectional, observational survey AWARE (Adults With Atopic Dermatitis Reporting on their Experience) studies of patients with AD. Patients provided a written response to the following question: Please take a few minutes to think about your atopic dermatitis, its effect on your life, and how you feel about it. What are some words that best describe the impact of atopic dermatitis on your life?

Prior to administration, the question was translated to the local language in each country; responses were then translated to English to facilitate the analysis.

Natural Language Processing

Single words that described the impact of AD on the patient's life were extracted from the open-ended responses; a corpus (collection of words) was created with word occurrence frequency using a tagging and lemmatization (headword identification) tool (WinTreeTagger for the USA and R Software for non-USA). Descriptive analysis evaluated character length, word count, and stop word (common words) count (Excel in the USA and R Software in non-USA). Using a stop word to total words ratio, keywords were extracted for analysis and a term-document matrix (TDM) was created. A word cloud was generated using R software (USA and non-USA). Co-occurrence identified words with the highest degree of centrality (TreeCloud and IramutQ software for the USA and R Software for non-USA). Centrality analysis was based on words with a frequency of more than 12 for the USA and more than 20 for non-USA.

RESULTS

USA

Of the 1519 survey participants recruited in the USA, 639 responded (Table 2). The most frequently used words describing the impact of AD included itch (37%), embarrassed (37%), annoyed (35%), pain (25%), and frustration (22%), as shown in Fig. 1a, b. The words annoyed and itch had the highest centrality (Fig. 1c). Concepts linked to annoyed included itch, embarrassed, distracted, inconvenient, and frustration. Concepts linked to itch included ugly, dryness, and red. Patients with moderate-to-severe AD commonly used the words depressed, anxious, worry, and hopeless to describe the impact of AD (Fig. 1d).

Non-USA

Of the 1444 survey participants in non-US countries, 592 responded (Table 2). The most frequently used words for describing the impact of AD included itch (24%),

Table 2 Baseline demographics

| | Total | Mild AD | Moderate-to-severe AD |
|---------------------------------|-------------|-------------|-----------------------|
| USA | | | |
| Number of respondents, <i>n</i> | 639 | 260 | 379 |
| Age, years, mean (SD) | 42.2 (16.9) | 42.8 (17.7) | 41.9 (16.4) |
| Female, % | 65.4 | 61.2 | 68.3 |
| Non-USA | | | |
| Number of respondents, <i>n</i> | 592 | 196 | 396 |
| Age, years, mean (SD) | 38.1 (13.5) | 38.7 (14.4) | 37.8 (13.0) |
| Female, % | 57.9 | 66.8 | 53.5 |

AD atopic dermatitis, SD standard deviation

uncomfortable (17%), annoyed (15%), pain (14%), life (12%), and embarrassed (11%), as shown in Fig. 2a, b. Itch and pain had the highest centrality (Fig. 2c). Concepts linked to itch included pain, frustration, sleep, feel, dry, and red. Concepts linked to pain included uncomfortable, embarrassed, annoyed, frustration, and tired. Words commonly used by patients with moderate-to-severe AD included itch, tired, pain, uncomfortable, and annoyed (Fig. 2d).

DISCUSSION

Although a large body of quantitative evidence measuring AD burden on patients is available, the impact of disease, as described by patients from the experiential level, has not yet been fully explored. This study, through the approach of NLP, evaluated the impact of AD on patients' lives as per their personal experience and choice of words. By uncovering word patterns and important trends of experiences, we found that patients not only face a physical burden but also a substantial emotional burden due to their AD.

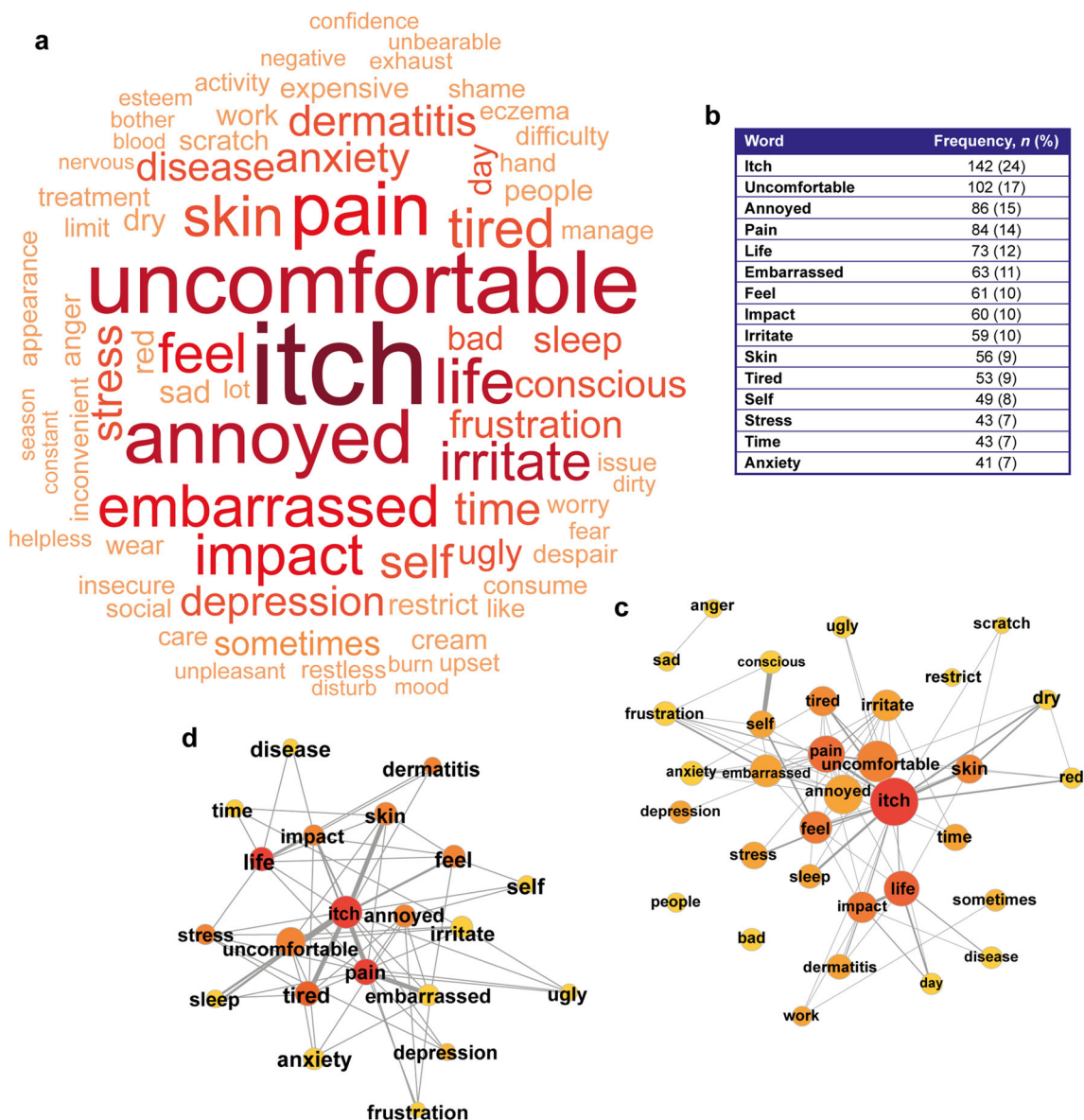


Fig. 1 Text-mining analysis of US data. **a** Word cloud. **b** Frequency of words used by patients to describe AD. **c** Tree cloud showing centrality in all AD severity groups.

d Tree cloud for patients in moderate-to-severe AD group. AD atopic dermatitis

Patients with AD were frequently impacted by itch, pain, and embarrassment. Sleep was strongly linked to itch in non-US patients, rather than pain (Fig. 2c), signifying that the need to frequently itch led to sleep disturbances and fatigue in patients [14]. For patients with moderate-to-severe AD, tired was linked to both sleep (non-USA, Fig. 2d) and depression (USA, Fig. 1d) or anxiety (non-USA, Fig. 2d), indicating that physical tiredness from sleep

disturbances may trigger stress, anxiety, and depression (Figs. 1d, 2d). This association was implied in previous studies [14]; our qualitative analysis explicitly linked the burden of sleep disturbance and fatigue to the emotional burden of depression in patients with AD. In patients in the USA with moderate-to-severe AD, depression was also linked to emotions of being hopeless and tired (Fig. 1d).

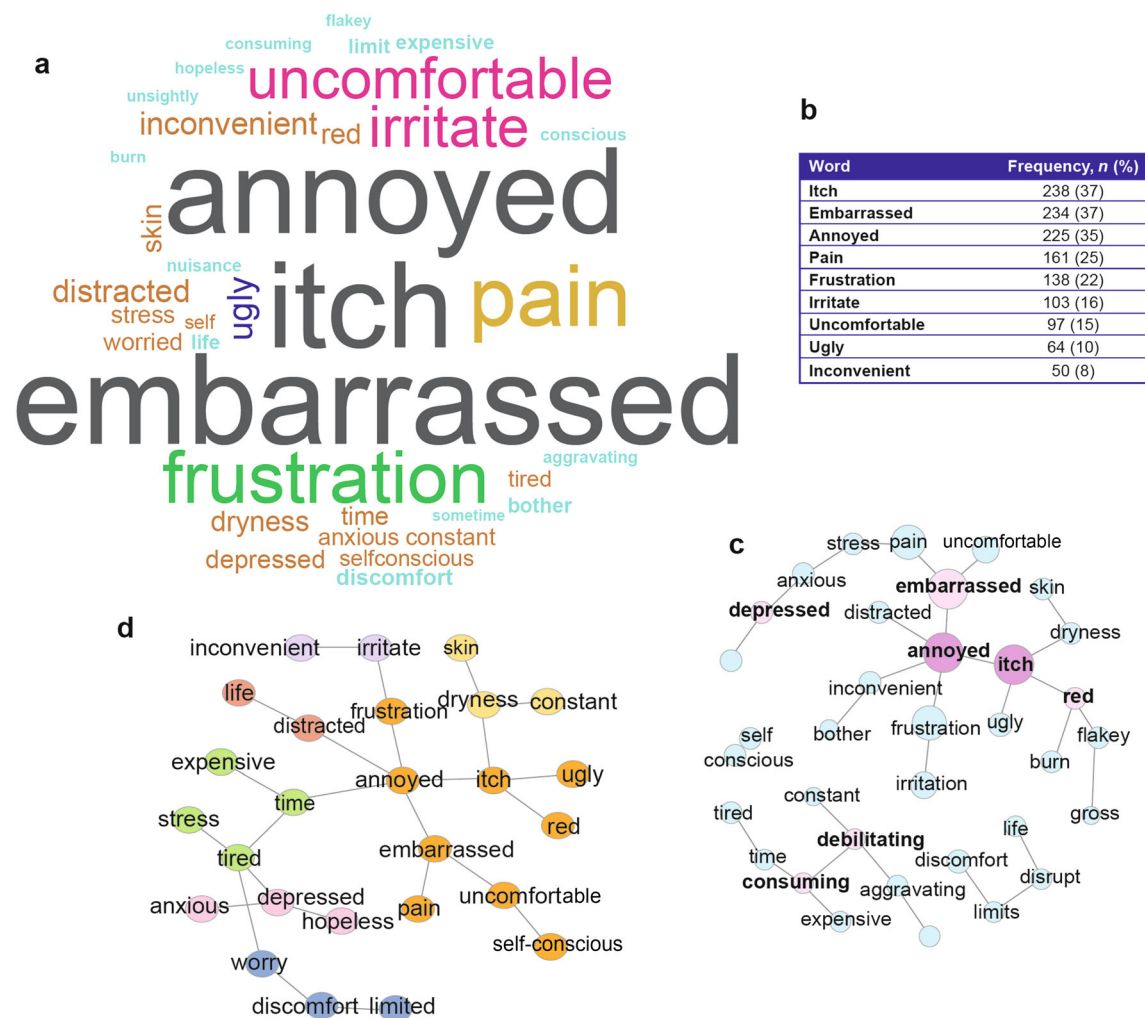


Fig. 2 Text-mining analysis of global data from France, Germany, Italy, Spain, the UK, and Canada. **a** Word cloud. **b** Frequency of words used by patients to describe AD. **c** Tree cloud showing centrality based on words with frequency greater than 20 in all AD severity groups. **d** Tree

cloud for patients in moderate-to-severe AD group (size of circle denotes word frequency, red denotes words with higher centrality, width of links denotes number of co-occurrences). AD atopic dermatitis

The use of ugly was linked to itch in US (Fig. 1c, d) and non-US (Fig. 2c, d) patients; this reflects the negative self-image that AD induces in patients. While previous studies have recognized itch as a physical burden [14], this emotional burden of itch was not captured. Pain was linked to itch in non-US patients (Fig. 2c, d), but also strongly linked to embarrassment and annoyance in both US and non-US patients (Fig. 1c, d and Fig. 2c, d), suggesting that pain is not only a physical characteristic of AD [14] but also distinctly associated with emotional

distress. Of note, despite the US and non-US studies being conducted sequentially with different analytical tools, the concepts elicited were similar.

The importance of patient-reported outcomes in optimizing disease management is well established [15]. NLP and centrality analysis assisted in uncovering an otherwise implicit and overlooked pool of knowledge on the patient experience that cannot be fully captured with standardized outcome measures such as the SCORing Atopic Dermatitis (SCORAD) tool

[16], Dermatology Life Quality Index (DLQI) [17], Patient-Oriented Eczema Measure (POEM) [18], and Eczema Area and Severity Index (EASI) [19]; these measures are better applied in assessing AD severity [20]. Specifically, SCORAD and POEM focus on itch and sleep, whereas our approach has shown that pain is also a symptom of AD that greatly impacts patients' lives. Although DLQI assesses pain, it is only assessed in relation to itch; our results support the notion that pain should also be evaluated distinctly from itch. These findings urge the need to incorporate patients' perceptions in AD assessment tools, such as the Atopic Dermatitis Control Tool [21]. Although our study did not identify all patient-reported consequences of AD, such as the known impact of AD on sexual health [22], our qualitative approach has provided an understanding of patient perceptions and the underlying range of physical and emotional consequences of AD, which can inform shared decision-making. These findings suggest the need for broader assessment of the impact of AD on patients' lives.

CONCLUSIONS

Through the approach of NLP, we have been able to identify the far-reaching consequences of AD on patients' lives, beyond the outcomes reported in standardized patient-reported and clinical measures. It is anticipated that a better understanding of the patient experience will enhance patient-physician communication and, ultimately, the management of AD.

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Compliance with Ethics Guidelines. Data collection was according to ethical codes of the British Healthcare Business Intelligence Association, European Society for Opinion and Marketing Research (ESOMAR) and European Pharmaceutical Market Research Association (EphMRA), and was compliant with the US Health Insurance Portability and Accountability Act (HIPAA) of 1996. The study was approved at country level by the appropriate ethics committees (Canada: Research Review Board INC [07 June 2016] and Health Research Ethics Board of Alberta [04 January 2017]; France: Advisory Committee on Information Processing in Material Research in the Field of Health [12 July 2016] and National Commission for Computing and Liberties [26 October 2016]; Germany: Medizinische Hochschule Hannover [6 June 2016]; Spain: Hospital de la Santa Creu I Sant Pau [8 June 2016]; UK: Research Ethics Committee [29 September 2016] and Health Research Authority [9 December 2016]). All participants provided informed consent.

Data Availability. All data generated or analyzed during this study are included in this published article/as supplementary information files.

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