ORIGINAL RESEARCH

Healthcare Resource Utilization and Direct Cost of Patients with Atopic Dermatitis in Dubai, United Arab Emirates: A Retrospective Cohort Study

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ABSTRACT

Introduction: Atopic dermatitis (AD) data are scarce in Dubai [United Arab Emirates (UAE)]. Therefore, this study aimed at understanding real-world healthcare resource utilization (HCRU) and related costs, specialties, treatment landscape, consultation-based prevalence and incidence, and patient characteristics.
Methods: This retrospective, longitudinal, insurance e-claims (Dubai Private Insurance—insured expatriates) database studied AD in Dubai between 1 January 2014 and 31 March

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2020. Two cohorts of patients based on treatment status as the eligibility criteria were selected from 442,956 patients with at least two AD diagnosis claims: treated AD [mild to moderate (10,134 patients) and moderate to severe (3515 patients)] and untreated or on drugs not included in the treated AD cohort (10,806 patients).
Results: Across treated AD (mild to moderate and moderate to severe) and untreated AD cohorts, mean age was ∼ 29 years; the majority were from dermatology (65–44%) and pediatrics (29–32%) specialty. Key HCRU cost contributors were hospitalizations and outpatient visits in both the treated AD groups. Mean annual disease-specific HCRU cost per patient was highest for the moderate-to-severe treated (531.5 USD) cohort, followed by the mild-to-moderate treated (378.4 USD) cohort, and lowest for the untreated (144.0 USD) cohort; patients with AD with any infection, asthma, or allergic rhinitis showed a similar trend. However, AD-diagnosed patients with *Staphylococcus* infection had the highest mean HCRU cost among the mild-to-moderate treated AD cohort, followed by the moderate-to-severe treated AD cohort.
Conclusion: This study indicated AD to be a common skin disease with a prevalence rate of 4–5% in Dubai (UAE), with the majority of patients (about 90%) being treated by specialists. However, there is a significant underuse of newer innovative therapies (including biologics). Also, disease severity (moderate-to-severe AD) was associated with high direct medical cost, which could be

controlled by early intervention. Furthermore, AD treatment choice could focus on major direct HCRU cost contributors such as hospitalizations, comorbid conditions, and infections.

Keywords: Atopic dermatitis; Healthcare resource utilization; Direct medical cost; Dubai; Health policy; Real-world study; Claims database

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Key Summary Points

Why carry out this study?

The data on burden of atopic dermatitis (AD) in the Middle East region, particularly in the United Arab Emirates (UAE), are scarce, so this retrospective study aimed to address the existing knowledge gap and inform the local and regional healthcare guidelines for AD management

The objective of this study was to understand the real-world direct medical costs among insured expatriate patients with AD from Dubai, in terms of healthcare resource utilization (HCRU) and related costs, specialties that diagnose AD, and treatment landscape. Consultation-based prevalence and incidence rates, as well as patient characteristics in terms of demographic characteristics and disease severity, were also analyzed

What was learned from the study?

The results of this study indicated a prevalence rate of AD in Dubai (UAE) of 4–5%. There exists significant underuse of the newer innovative therapies (such as biologics), although a majority of patients are being treated by specialists

The high medical direct cost incurred by AD in terms of HCRU is mainly due to the severity of the disease (moderate-to-severe AD), which could be controlled by early intervention. The choice of AD treatment can focus on major direct cost contributors such as hospitalizations, comorbidities, and infections

INTRODUCTION

Atopic dermatitis (AD) is a relapsing–remitting, chronic inflammatory skin disease characterized by recurrent eczematous lesions and pruritus [1–3]. AD typically appears during childhood, with approximately 85–90% cases being diagnosed before the age of 5 years, and the patients may attain remission before adulthood [4]. However, in some cases, AD may persist or relapse or may even have an onset in adulthood and may be difficult to treat [4].

The prevalence of AD is about 15–20% among children and 1–3% among adults [5], and varies widely across the globe owing to regional, country-specific, age-group-specific, and data-capturing methodological differences [6]. Evidence from several studies suggests that AD prevalence has reached a plateau in developed countries, whereas it continues to rise in low-income countries [5, 7–10].

Management of AD begins with topical corticosteroids (TCS) followed by topical calcineurin inhibitor (TCI) such as pimecrolimus and tacrolimus, followed by later lines of therapy such as topical therapy of phosphodiesterase 4 inhibitor (crisaborole 2% ointment), systemic immunosuppressants, antimicrobials, phototherapy, and allergen-specific immunotherapy [3, 11, 12]. Recent approved additions to treatment management of AD includes biologics (such as dupilumab, tralokinumab) and JAK inhibitor (such as ruxolitinib, upadacitinib, abrocitinib) [13–17]. The first biologic for AD treatment, dupilumab, was approved in 2017 [18]. Dupilumab, an interleukin-4 (IL-4) receptor alpha antagonist, has proven to be a safe drug for AD in all age groups, including adolescents from the age of 12 and elderly patients, as well as during the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) pandemic [18–23]. Alongside the initial lines of therapy, the basic therapy in the Middle East region includes use of emollients, trigger avoidance, and patient education [3].

Patients with AD are at increased risk of infections (such as *Staphylococcus* infection). Also, AD predisposes patients to abnormal immune response that may lead to cause atopic

march, resulting in asthma and rhinitis [24–29]. The intermittent infection among patients with AD substantially impacts individuals' overall health status and quality of life [30, 31], along with increased utilization of healthcare resources [32]. The cost estimation (including both direct and indirect cost) for AD treatment in the USA was about 5 billion USD annually [33]. Another US study estimated 8.3 billion USD as the annual hospitalization cost incurred from 2002 to 2012 by patients with AD or eczema as primary diagnosis [34]. Although several global studies have indicated an increasing prevalence [5, 35, 36] and associated healthcare burden [31, 37, 38], there is a paucity of evidence on the burden of AD in the Middle East region, particularly in the United Arab Emirates (UAE).

The objective of the current study was focused at understanding the real-world economic burden of insured expatriates AD in terms of direct medical cost [healthcare resource utilization (HCRU) and related costs], specialties that diagnose AD and treatment landscape. This study also analyzed consultation-based prevalence and incidence rates, as well as patient characteristics in terms of demographic characteristics and disease severity. Also, this study aimed to address the existing knowledge gap and inform the local and regional healthcare guidelines for AD management.

METHODS

Data Source

The data in this study were extracted from the insurance e-claims data of Dubai Real-World Database (DRWD). Approximately 80% of population in Dubai is covered by private insurance (predominantly comprising the expatriate community), and thus, the DRWD captures nearly 100% of those who are under private insurance. The DRWD is an anonymous patient-level database of all insurance e-claims generated for expatriates from the private healthcare sector (e.g., private clinics, hospitals, etc.) in the Emirates of Dubai (UAE). The database contains information on patient demographics and direct medical costs such as diagnoses, procedures (medical, surgical, and diagnostic), prescriptions, and other related services. The study data are as obtained on the basis of information available in DRWD from the third-party payer and patients' perspective.

Study Population and Design

This was a longitudinal, retrospective, secondary data analysis study of insurance e-claims database (DRWD) from Dubai (Dubai Private Insurance). The study design is shown in Fig. 1. The data collection period for all patients was from 1 January 2014 to 31 March 2020 (study period), involving 12-month data before and after the index period (pre-index and post-index periods, respectively) for data analysis. The patients with an AD diagnosis were identified during the index period (study identification period) of 1 January 2015 to 31 March 2019.

In this study, a total of 442,956 patients with at least two AD diagnoses during the study period were identified. Included patients in two cohorts were stratified by treatment status: treated AD cohort and untreated or on drugs not included in the treated AD cohort. The treated AD cohort consisted of all AD-diagnosed patients included for analysis during the study period, who had first AD treatment during the index period (1 January 2015 to 31 March 2019). These patients from the treated AD cohort were further categorized on the basis of severity recorded in the e-claims database into the two subgroups of mild-to-moderate treated AD ($n = 10{,}134$ patients) and moderate-to-severe treated AD (3515 patients). Untreated or on drugs not included in the treated AD cohort consisted of all AD-diagnosed patients who either did not receive any treatment for AD or did not receive the treatment considered for analysis of the treated AD cohort (10,806 patients). In this untreated or on drugs not included in the treated AD cohort, analysis was performed during the study period; first diagnosis of AD was during the index period (i.e., 1 January 2015 to 31 March 2019). Also, analysis was performed for the patients with AD who had asthma, rhinitis, any infection, or *Staphylococcus aureus* infection. Refer to Supplementary Tables 1–3.
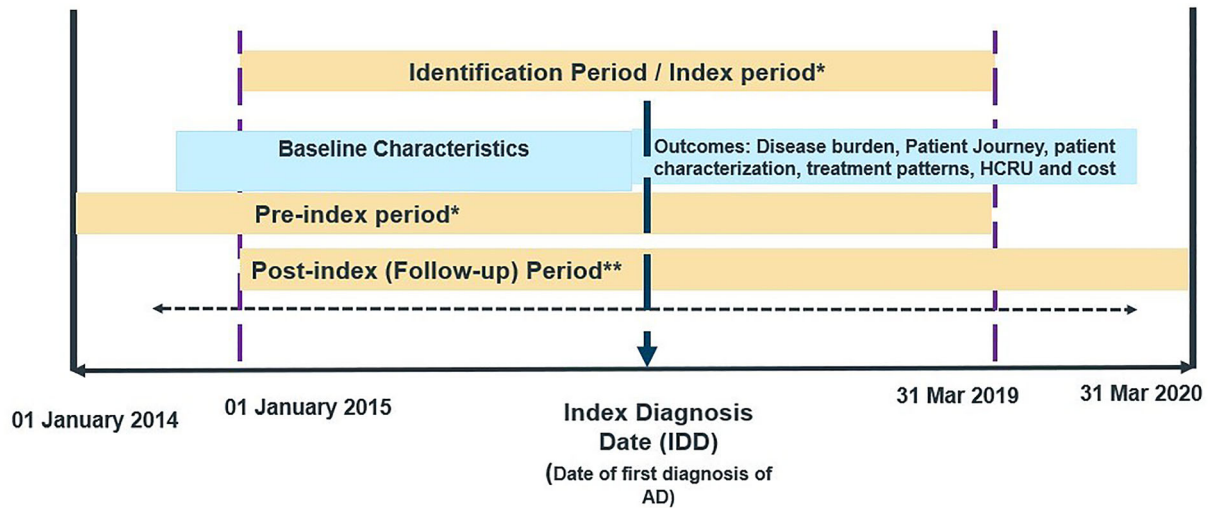
Fig. 1 Overview of study design. *Pre-index and post-index follow-up period will vary across patients on the basis of the index diagnosis date (IDD). The 12-month period prior to the IDD was termed the pre-index period, while the 12-month period following the IDD was termed the post-index (follow-up) period. **Patient must not have had more than 6 months gap between any two service claims during either the pre-index of the post-index (follow-up) periods (a surrogate for continuous enrollment). *AD* atopic dermatitis, *HCRU* healthcare resource utilization, *IDD* index diagnosis date

Inclusion and Exclusion Criteria

This study included patients from all the age groups (≥ 3 months), who had at least two AD diagnoses (i.e., denoted by one or more of the ICD-10-CM codes listed in Supplementary Table 4) during the study period. Selection of patients and inclusion in specific cohorts (treated AD and untreated AD) was decided on the basis of the patients' treatment status (treated or untreated) and therapies prescribed. Given the limited registered clinical disease data in the e-claims database, treatments received were used as surrogate for determining the disease severity, similar to the methodology described in the publication by Shrestha et al. [37]. There was no other specific exclusion applied for selection of the broader patient population. However, exclusion criteria were applied to select patients into the two subcohorts (mild-to-moderate treated AD and moderate-to-severe treated AD) on the basis of their disease severity (Supplementary Tables 1–3).

The mild-to-moderate treated AD cohort (10,134 patients) included patients who received treatment with TCI (pimecrolimus cream or tacrolimus ointment) or TCS (very high potency, high potency, medium potency, lower medium potency, low potency, and lowest potency) during the index period (1 January 2015 to 31 March 2019). The potency of TCS was defined on the basis of the concentration of the active ingredient and type of formulation. The moderate-to-severe treated AD cohort (3515 patients) included patients who received treatment with corticosteroids (including TCS of all potencies), biologics, systemic immunosuppressants (cyclosporine, methotrexate, azathioprine, and mycophenolate mofetil), and phototherapy during the index period. The criteria for selection of patients in these subgroups are presented in Supplementary Tables 1–3.

Ethical Considerations

Ethics committee approval or obtaining informed consent from patients was not required for this study, as this study did not involve the collection, use, or transmittal of individual identifiable data. Also, DRWD contains anonymized structured insurance e-claims data of the patients. Patients' identity or medical records were not disclosed for the purposes of this study, except where disclosure was

allowed as per applicable law. The study conformed to the ethical principles outlined in the Good Pharmacoepidemiology Practices Guidelines, Declaration of Helsinki 1964 and its later amendments, Good Epidemiological Practice guidelines issued by the International Epidemiological Association, Good Practices for Outcomes Research issued by the International Society for Pharmacoeconomics and Outcomes Research, and other applicable guidelines.

Both the dataset and the security of the office where the dataset was kept met the requirements of the Health Insurance Portability and Accountability Act of 1996. IQVIA had the accessibility to DRWD owned by Dubai Health authority (DHA) and was used only for the analysis purpose.

Study Measures and Treatment Outcomes

Patient Characteristics (Demographics and Disease Severity)
Demographics were characterized in terms of patient's age (latest available age at the time of data extraction), gender, and disease severity type.

Consultation-Based Prevalence and Incidence Rates
Consultation-based prevalence and incidence rates were calculated as percentage based on the number of consultation-based prevalence or incidence (per ICD-10 CM codes, refer to Supplementary Table 4) against the total number of patients in the e-claims database.

Diagnosis and Treatment Consultations by Specialty Type
Different types of specialties in charge of diagnosis of patients with AD were analyzed on the basis of the patients identified in the treated AD cohort (mild to moderate and moderate to severe) and untreated or on drugs not included in the treated AD cohorts.

Treatment Landscape
The treatment landscape (patterns) was evaluated for the drug classes including corticosteroids, systemic immunosuppressants, TCIs,

antihistamines, and biologics. Further, the prescription share by drug class, prescription share by drug product, and treatment switching patterns for the different drug classes were assessed. The corticosteroids as a class included injections, tablets, cream, gel, syrup, spray, ointment, lotion, drops, etc. Systemic biologics (interleukin-4 receptor alpha antagonist) included dupilumab (licensed in UAE in 2017). Antihistamines were available as tablets, syrups, solutions, drops, injections, etc.

Healthcare Resource Utilization (HCRU) and Associated Costs
The HCRU and associated costs were determined on the basis of encounter type [inpatient (hospitalization), outpatient, and emergency visits] and activity types [medication, procedures, supplies and consumables, services, and diagnosis-related group (DRG)]. The costs in this study were assessed as gross cost, which included a combination of net cost and patient share.

The HCRU and associated costs were evaluated for all-cause and AD-related. The HCRU data pertaining to all types of health visits and services availed during the post-index period [12 months following the index diagnosis date (IDD)] were extracted, and related costs were computed for both cohorts. Additionally, the baseline HCRU and associated costs were assessed for all the identified patients.

Statistical Analyses

Analysis Sets
Overall population: The consultation-based incidence and prevalence were estimated using the overall AD population and stratified by age group.

AD subgroups based on treatment status and severity: This analysis set included patients stratified into the treated AD cohort (mild to moderate and moderate to severe) and untreated or on drugs not included in the treated AD cohort.

Analytical Technique
Descriptive statistics were used to analyze the outcomes of the study (no predefined

hypothesis was tested). No data imputation technique was applied in this study. Study variables included patient characteristics [demographics (age and gender) and disease severity], consultation-based incidence and prevalence of AD, patients' diagnosis and treatment consultation by specialties type, treatment landscape, and HCRU and related costs. Continuous variables were calculated using number of observations, mean, median, and standard deviation (minimum and maximum), as appropriate. Categorical variables were calculated by frequency and percentages, and by subgroups, where appropriate. In this study, all costs were captured from DRWD as United Arab Emirates Dirham (AED), which has been converted to United States dollar (USD) using conversion factor (1 USD = 3.6725 AED, exchange rate as of 18 February 2022) [39].

RESULTS

Participants

A total of 850,867 patients were identified from the DRWD with at least one AD diagnosis, of which 442,956 patients had least two AD diagnoses during the study period. Further, based on treatment status and disease severity, patients were divided into treated AD cohort [mild-to-moderate treated AD ($n = 10{,}134$ patients); moderate-to-severe treated AD ($n = 3515$ patients)] and untreated or on drugs not included in the treated AD cohorts ($n = 10{,}806$ patients) (Supplementary Tables 1–3).

Patient Characteristics Including Demographics and Disease Severity

Across all the cohorts, data on age and gender were available for only about half of the eligible patients (49.5%, 51.8%, and 45.8% of patients from treated AD cohort of mild-to-moderate, moderate-to-severe, and untreated or on drugs not included in the treated AD cohort, respectively; refer to Table 1 for details). From the available data on age, approximately 65% of patients were above 18 years of age (64.5%,

61.9%, and 65.0% of mild-to-moderate treated AD cohort, moderate-to-severe treated AD cohort, and untreated or on drugs not included in treated AD cohort, respectively), 20% were between 6 and 11 years of age, nearly 10% were within 2–5 years of age, and 5–8% of them were within 12–17 years of age (Table 1). The mean [standard deviation (SD)] age of the patients in the mild-to-moderate AD cohort, the moderate-to-severe AD cohort, and the untreated or on drugs not included in the treated AD cohort was 29.1 (18.1) years, 28.7 (18.2) years, and 29.2 (18.0) years, respectively. From the available data on gender across cohorts, a higher proportion of patients with AD were male (57–61%) than female (39–43%).

Across the treated AD cohorts of patients during the pre-index period, dermatology specialty shared a majority (62.2–65.3%) of the AD-treated patients, followed by pediatrics specialty (28.8–31.7%). Refer Table 1 for details.

During the pre-index period, among the treated patients with AD who were hospitalized, asthma was noted in 4.5% (38 patients) of mild-to-moderate treated AD patients, and 5.5% (16 patients) of moderate-to-severe treated AD patients.

Consultation-Based Incidence and Prevalence of AD

Incidence

Overall, an increase in percentage of incident AD cases were observed during the study period (1 January 2014 to 31 March 2020) between 3.5% (2014) and 4.7% (2016). Overall, an upward trend in incidence between 2014 and 2016, and a declining trend for the subsequent years until March 2020, was observed (Table 2). Similar to the overall incidence rate when split by age group, an upward trend in percentage of incidence cases for the age groups of 12–17 years (5.6–6.8%) and 18+ years (2.8–4.7%) was observed between 2014 and 2016, whereas for the subsequent years until March 2020, a declining trend was observed within these age groups (12–17 years: 6.0–1.8%; 18+ years: 4.2–1.3%). For the 2–5 years age group, the percentage increased until 2015 (3.0–36.1%)

Table 1 Demographics and baseline patient characteristics

Baseline characteristics	Treated AD cohort—mild to moderate	Treated AD cohort—moderate to severe	Untreated or on drugs not included in the treated AD cohorts
Overall study population (*N*)	10,134	3515	10,806
Age (latest available age at the time of data abstraction) [*n* (%)]			
2–5 years	567 (11.3%)	196 (10.8%)	553 (11.2%)
6–11 years	924 (18.4%)	357 (19.6%)	892 (18.0%)
12–17 years	292 (5.8%)	141 (7.7%)	288 (5.8%)
≥ 18 years	3234 (64.5%)	1128 (61.9%)	3219 (65.0%)
Missing	5117 (50.4%)	1693 (48.1%)	5854 (54.1%)
Gender [*n* (%)]			
Male	3002 (59.8%)	1113 (61.1%)	2825 (57.0%)
Female	2015 (40.2%)	709 (38.9%)	2127 (43.0%)
Missing	5117 (50.4%)	1693 (48.1%)	5854 (54.1%)
Specialty [*n* (%)]			
Dermatology	6309 (62.2%)	2297 (65.3%)	4777 (44.2%)
Pediatrics	3214 (31.7%)	1013 (28.8%)	3266 (30.2%)
IM-allergy/immunology	66 (0.6%)	27 (0.7%)	35 (0.3%)
General practice/family medicine	2948 (29.0%)	898 (25.5%)	2644 (24.4%)
Others (specialties such as alternative medicine, anesthesiology, obstetrics, gynecology, etc.)	2048 (20.2%)	606 (17.2%)	1679 (15.5%)
Baseline mean (SD) all-cause healthcare utilization (visits): by encounter type			
Overall	23.4 (21.6)	35.0 (28.6)	15.3 (13.5)
Inpatient	1.8 (1.9)	2.7 (2.8)	1.5 (3.0)
Inpatient (asthma-related)	1.5 (0.7)	2.1 (0.6)	1.2 (0.6)
Inpatient (allergic rhinitis-related)	1.3 (0.5)	1.8 (0.5)	1.1 (0.4)
Outpatient	22.7 (21.1)	34.1 (28.0)	14.8 (12.8)
Emergency	3.8 (4.6)	5.3 (6.2)	3.0 (3.2)
Baseline mean (SD) all-cause healthcare utilization (costs): by encounter type			
Inpatient	12,982 (49,370)	19,839 (80,436)	10,111 (18,793)
Inpatient (asthma-related)	7174 (6967)	8271 (5452)	6662 (7485)
Inpatient (allergic rhinitis-related)	6184 (5439)	10,987 (9738)	4405 (4234)
Outpatient	6157 (10,030)	9173 (14,159)	4580 (7972)

Table 1 continued

Baseline characteristics	Treated AD cohort—mild to moderate	Treated AD cohort—moderate to severe	Untreated or on drugs not included in the treated AD cohorts
Emergency	1262 (1578)	1698 (2018)	997 (1204)

AD atopic dermatitis, *IM* internal medicine, *n* number of patients, *N* total sample analyzed, *NA* not applicable, *SD* standard deviation

and declined during subsequent years until March 2020 (21.9–2.5%). However, for the age group of 0–1 year, there was a fluctuation in the percentage of consultation-based incidence AD cases, whereas incidence rates showed a declining trend over the years for the age group of 6–11 years (10.0–1.8%) from 2014 until March 2020 (refer to Supplementary Table 5).

Prevalence

The overall percentage of consultation-based prevalence cases remained steady during the study period with an average of 4.3% from 2015 to 2020 (inclusive, until March 2020). Prevalence was highest at 5.2% (2016) and lowest at 4.3% in 2019 (2.4% between January 2020 and March 2020) (Table 3). A slight decline in prevalence during 2018–2019 after a slight increase in 2016 and 2017 was noted. For the age groups of 6–11 years, 12–17 years, and 18+ years, the prevalence remained stable with slight increase in 2016 and 2017, followed by slight decline in subsequent years. However, highest prevalence was observed in the age group of 0–1 year, with a declining trend among

the age group of 2–5 years. Supplementary Table 6 presents the prevalence of AD by age group.

Treatment and Switching Patterns among Patients with AD in Dubai

The assessments of the treated patients with AD were based on prescription of drug classes of corticosteroids, systemic immunosuppressants and TCIs, antihistamines, and biologics. Corticosteroids included all the forms, i.e., injections, tablets, cream, gel, syrup, spray, ointment, lotion, drops, etc.

Mild-to-Moderate Treated AD Cohort

The most prescribed drug class in the mild-to-moderate AD group was corticosteroids (14,740 claims) with the majority as TCS (14,139 claims), followed by claims for antihistamines (7689 claims) and TCI (1859 claims). Within the TCS, the highest claims were made for medium-potency TCS ($n = 6935$) followed by high-potency TCS ($n = 3093$), lowest-potency TCS ($n = 2637$), and lower-medium-

Table 2 Incidence of AD in the insured population of Dubai (2014–2020) based on claims data

Consultation-based incidence	2014	2015	2016	2017	2018	2019	2020 (till March)
Number of patients in e-claims database	1,604,471	2,157,519	2,972,033	3,977,401	4,458,644	4,730,769	2,390,742
Number of consultation-based incidence cases	57,449	95,478	139,785	167,962	168,370	177,570	44,253
Percentage of consultation-based incidence cases against number of patients in e-claims database	3.5%	4.4%	4.7%	4.2%	3.7%	3.7%	1.8%

Table 3 Prevalence of AD in the insured population of Dubai (2014–2020) based on claims data

Consultation-based prevalence	2014	2015	2016	2017	2018	2019	2020 (till March)
Number of patients in e-claims database	1,604,471	2,157,519	2,972,033	3,977,401	4,458,644	4,730,769	2,390,742
Number of consultation-based prevalence cases	–	103,402	156,594	191,809	198,697	207,074	57,617
Percentage of consultation-based prevalence cases against number of patients in e-claims database	–	4.7%	5.2%	4.8%	4.4%	4.3%	2.4%

potency TCS ($n = 1340$), and the least claims for very-high-potency TCS ($n = 1180$). As per the selection criteria for this cohort of patient, claims for medications from any other drug class were not applicable.

Treatment switch pattern assessment within TCS and TCI from first-line treatment to second-line treatment during the 1-year follow-up period indicated a higher ($n = 178$) number of patients switching from the first-line therapy of TCS to second-line TCIs than vice versa ($n = 112$). Of these 178 switches from first-line TCS to second-line TCI, the highest number of switches were from medium-strength TCS (79 treatments), followed by lowest-strength TCS (37 treatments), high-strength TCS (30 treatments), and lower-medium-strength TCS (24 treatments), and the least from very-high-strength TCS (8 treatments). Similar to switch pattern from first-line TCS to second-line TCI split by strength, the switch pattern of 112 switches of first-line TCI to second-line TCS also had the highest switches involving medium-strength TCS (44 treatments), followed by lowest-strength TCS (32 treatments), high-strength TCS (15 treatments), and lower-medium-strength (13 treatments), and the least from very-high-strength TCS (8 treatments).

Switch pattern assessment within TCS and TCI from second-line treatment to third-line treatment indicated a higher number of patient switches from second-line TCIs to third-line TCS than vice versa ($n = 7$). Of the 38 switches from second-line to third-line TCI and TCS ,

the highest switch was to medium-strength TCS ($n = 19$), followed by high-strength TCS ($n = 7$) and lower-medium-strength TCS ($n = 6$), and three treatment switches to very high and lowest TCS, each. Of the seven switches from second-line TCS to third-line TCI, the lowest strength dominated ($n = 4$), followed by two treatments from medium-strength TCS to one very-high-strength TCS.

In terms of first add-on therapy within TCS and TCI, higher number ($n = 107$) of patients with TCI was added to patients ongoing on TCS than vice versa ($n = 97$). The second add-on of TCS to an ongoing TCI was more ($n = 20$ patients) than vice versa (i.e., second add-on of TCI to ongoing TCS; $n = 5$). Refer to Table 4 and Figs. 2a and 3a.

Moderate-to-Severe Treated AD Cohort

The most prescribed drug class in the moderate-to-severe AD group was corticosteroids (8180 claims that included all the forms, i.e., injections, tablets, cream, gel, syrup, spray, ointment, lotion, drops, etc.), with majority claims for TCS (7529 claims), followed by anti-histamines (4227 claims). Within TCS, the highest claims were made for medium-potency TCS ($n = 3686$), followed by high-potency TCS ($n = 1755$), lowest-potency TCS ($n = 1351$), and lower-medium-potency TCS ($n = 717$), and was the least for very-high-potency TCS ($n = 684$). The other drug classes for which claims were made in moderate-to-severe treated AD group were biologics (22 claims of dupilumab) and

systemic immunosuppressants (4 claims) (Table 4).

Data available on switch pattern for moderate-to-severe treated patients with AD are insufficient to draw any conclusion. Refer to Figs. 2b and 3b for details.

Antihistamines (tablets, syrups, solutions, drops, injections, etc.) among treated patients with AD ranged between 62.0% (n = 6282) and 74.9% (n = 2633) in the mild-to-moderate and moderate-to-severe groups, respectively, during the study period (Supplementary Table 7). During the 1-year follow-up period, 52% of patients in the mild-to-moderate treated AD cohort had 7689 (47%) antihistamine claims and 65% of patients with moderate-to-severe treated AD cohort had 4227 (45%) antihistamine claims (Table 4).

Healthcare Resource Utilization (HCRU) and Associated Costs

AD-Related Healthcare Resource Utilization and Associated Costs per Patient (1 Year Follow-Up)

Overall, the mean (SD) AD-related HCRU per patient was highest in the moderate-to-severe cohort [6.5 (5.9)], followed by the mild-to-moderate treated AD cohort [4.9 (4.9)], and lowest in the untreated or on drugs not included in the treated AD cohort [1.8 (1.7)]. Similar to the HCRU, the overall annual HCRU direct cost also showed a trend toward highest mean AD-related HCRU gross cost (per patient) among moderate-to-severe treated AD cohort (531.5 USD) followed by the mild-to-moderate treated AD cohort (378.4 USD) and lowest for the untreated AD cohort (144.0 USD).

In line with the overall gross mean annual HCRU cost, even by encounter type (1 year follow-up), per patient direct annual HCRU costs was highest among the moderate-to-severe treated AD cohort, followed by the mild-to-moderate cohort, and lowest for the cohort untreated or on drugs not included in the treated AD cohort.

Furthermore, when assessed by encounter type, the mean gross costs were highest owing to hospitalization for AD-related claims among the moderate-to-severe treated AD (11,925.3 USD) followed by mild-to-moderate treated AD (10,502.3 USD) and untreated AD cohort patients (640.7 USD). Similarly, the mean gross costs incurred from outpatient visits for AD-related claims was highest among the moderate-to-severe treated AD (482.2 USD) followed by mild-to-moderate treated AD (345.2 USD), and untreated AD cohort patients (143.4 USD). Refer to Table 5 for details.

In terms of activity type, highest cost was incurred due to healthcare common procedure coding system (HCPC), followed by current procedural terminology (CPT), drugs, and services. Overall, direct annual HCRU cost by activity type among treated AD cohort was higher among patients from moderate-to-severe than mild-to-moderate cohort: HCPC (768.9 USD versus 538.0 USD, respectively), CPT (280.1 USD versus 197.1 USD, respectively), drugs (256.7 USD versus 196.5 USD), and services (202.0 USD versus 154.9 USD). Refer to Table 6 for details on activity type for encounter type.

AD-Related Healthcare Resource Utilization (by Visits and Costs) per Patient by Specialty

The patient share by top specialties during the 1-year follow-up period were dermatology, pediatrics, and general practice/family medicine (Supplementary Table 8). The AD-related utilization of healthcare resources for patients with comorbid conditions of asthma or allergic rhinitis could not be interpreted because of limited data available for analysis.

Healthcare Resource Costs per Patient by Any Infection

Among the AD-diagnosed patients with any infection, the HCRU was higher in the moderate-to-severe treated AD cohort than the mild-to-moderate AD cohort, and lowest for untreated or on drugs not included in the treated AD cohort. The main drivers of increased HCRU among patients with AD who had any infection in both the treated AD cohorts were outpatient and emergency room visits (Table 7). By activity type, the highest cost was attributed to HCPCS, CPT, and services.

Table 4 Treatment patterns among patients with AD in Dubai by number of claims

Treatment and switch pattern (by number of claims for AD)	Treated AD cohort—mild to moderate	Treated AD cohort—moderate to severe
Treatment patterns		
Corticosteroid	14,740	8180
Topical corticosteroid (TCS)	14,139	7529
TCI	1859	–
Antihistamines claims (tablets, syrups, solutions, drops, injections, etc.)	7689 (47%)	4227 (45%)
Number (%) of patients with antihistamine claims	5269 (52%)	2284 (65%)
Biologics	–	22
Systemic immunosuppressants	–	4
Methotrexate tabs (imported)	–	2
Methotrexate 2.5 mg	–	1
Imuran	–	1
Claims by drug product[a]		
Corticosteroids		
TCS		
FUCICORT cream (fusidic acid/hydrocortisone)	1556	872
ELOCOM cream (mometasone furoate)	1242	711
ELOCOM ointment or topical lotion (mometasone furoate)	1062	615
ADVANTAN cream or ointment (methylprednisolone aceponate)	1062	589
TCI		
Elidel (pimecrolimus)	955	–
Protopic (tacrolimus)	913	–
Systemic immunosuppressants		
Methotrexate tabs (imported)	–	2
Methotrexate 2.5 mg	–	1
Imuran (azathioprine)	–	1
Biologics		
Dupixent (dupilumab)	–	22

AD atopic dermatitis, *TCI* topical calcineurin inhibitors, *TCS* topical corticosteroids
[a]Top three claims

a

Switch From

Switch from first treatment (the switch from first treatment to second treatment)	Topical calcineurin inhibitors	Topical corticosteroid				
		Very High	High	Medium	Lower Medium	Lowest
Topical calcineurin inhibitors		8	15	44	13	32
Topical Corticosteroid						
Very High	8		-	-	-	-
High	30	-		-	-	-
Medium	79	-	-		-	-
Lower Medium	24	-	-	-		-
Lowest	37	-	-	-	-	

Switch From

Switch from 2nd therapy (the switch from second treatment to third treatment)	Topical calcineurin inhibitors	Topical corticosteroid				
		Very High	High	Medium	Lower Medium	Lowest
Topical calcineurin inhibitors		3	7	19	6	3
Topical Corticosteroid						
Very High	1		-	-	-	-
High	-	-		-	-	-
Medium	2	-	-		-	-
Lower Medium	-	-	-	-		-
Lowest	4	-	-	-	-	

b

Switch From

Switch from first treatment (the switch from first treatment to second treatment)	Biologics	Corticosteroid	Systemic immunosuppressants
Biologics		-	-
Corticosteroid	3		1
Systemic immunosuppressants	-	1	

Switch From

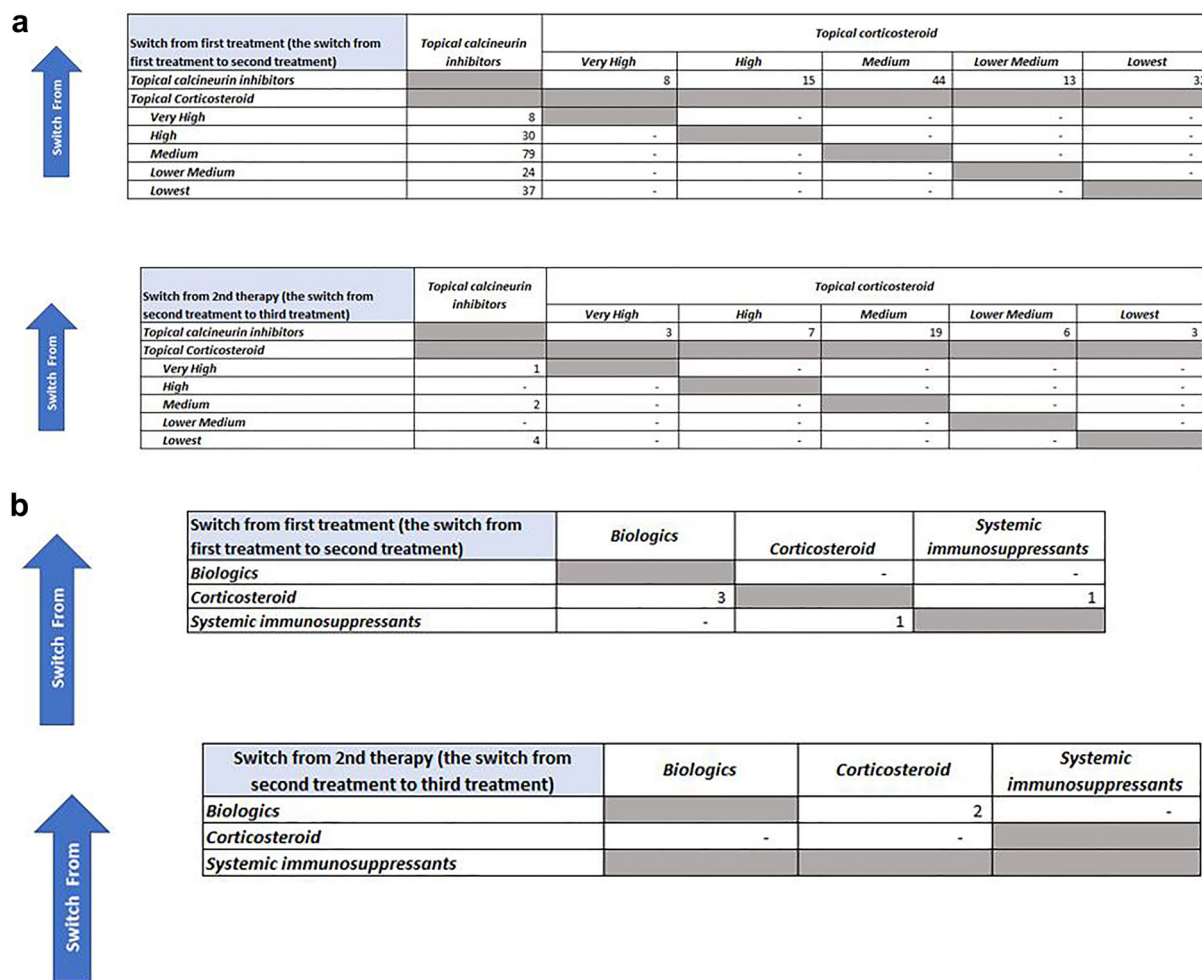| Switch from 2nd therapy (the switch from second treatment to third treatment)	Biologics	Corticosteroid	Systemic immunosuppressants
Biologics		2	-
Corticosteroid	-		-
Systemic immunosuppressants			

Fig. 2 Switching patterns (first and second treatment switch) for mild-to-moderate and moderate-to-severe treated AD cohorts. **a** Mild-to-moderate treated AD cohorts—first and second treatment switch. **b** Moderate-to-severe treated AD cohort—first and second treatment switch

In line with the HCRU, the gross mean annual costs (USD) among the patients with AD who have any infection were highest for the moderate-to-severe cohort followed by the mild-to-moderate cohort, and lowest for untreated or on drugs not included in the treated AD cohort. The main drivers of increased HCRU costs in both the treated AD cohorts were inpatient (hospitalization) and outpatient visits (Table 7). By activity type, highest cost was attributed to HCPCS, CPT, and services.

Patients with Staphylococcus Infection Complication

Among AD-diagnosed patients who had *Staphylococcus* infection (as identified using ICD-10-CM codes), the mean HCRU and associated costs were highest for the mild-to-moderate cohort (7.0 visits and 10,313.9 USD), followed by the moderate-to-severe cohort (6.0 visits and 8319.9 USD), and lowest for untreated or on drugs not included in the treated AD cohort (1.0 visit and 97.2 USD). Across the treated AD cohort, patients who had *Staphylococcus* infection, highest cost burden was due to the inpatient visits (hospitalization), followed by
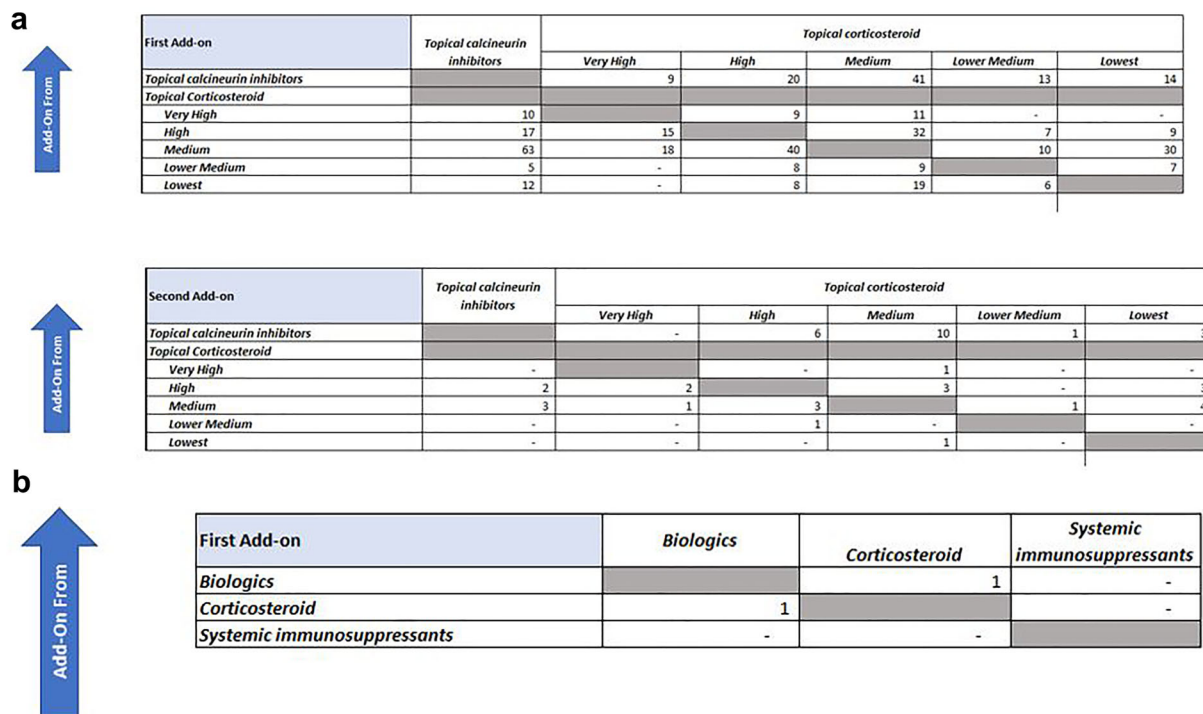
a

First Add-on	Topical calcineurin inhibitors	Topical corticosteroid				
		Very High	High	Medium	Lower Medium	Lowest
Topical calcineurin inhibitors		9	20	41	13	14
Topical Corticosteroid						
Very High	10		9	11	-	-
High	17	15		32	7	9
Medium	63	18	40		10	30
Lower Medium	5	-	8	9		7
Lowest	12	-	8	19	6	

Second Add-on	Topical calcineurin inhibitors	Topical corticosteroid				
		Very High	High	Medium	Lower Medium	Lowest
Topical calcineurin inhibitors		-	6	10	1	3
Topical Corticosteroid						
Very High	-		-	1	-	-
High	2	2		3	-	3
Medium	3	1	3		1	4
Lower Medium	-	-	1	-		-
Lowest	-	-	-	1	-	

b

First Add-on	Biologics	Corticosteroid	Systemic immunosuppressants
Biologics		1	-
Corticosteroid	1		-
Systemic immunosuppressants	-	-	

Fig. 3 Switching patterns (first and second add-on treatment) for mild-to-moderate and moderate-to-severe treated AD cohorts. **a** Mild-to-moderate treated AD cohort—first and second add-on treatment. **b** Moderate-to-severe AD cohort[a]—first and second add-on treatment. [a]Data on second add-on treatment not available

emergency, and lowest by outpatient visits. However, for untreated or on drugs not included in the treated AD cohort, highest cost burden was from inpatient visits, followed by outpatient, and lowest from emergency room visits.

Among mild-to-moderate treated AD cohort, the overall costs (in USD) among AD-diagnosed patients who had *Staphylococcus* infection by activity types were as follows: drugs (11,327.1), CPT (2094.7), HCPCS (325.1), services (5378.08), and unknown (2853.6). In the moderate-to-severe treated AD cohort, the overall costs by activity types for *Staphylococcus* infection were as follows: drugs (7561.8), CPT (1611.1), HCPCS (325.1), services (5378.0), and unknown (1462.2). Among untreated or on drugs not included in the treated AD cohort, the cost for *Staphylococcus* infection by activity type was as follows: drugs (37.30), CPT (49.82), and services (53.36).

All-Cause Healthcare Resources Utilization (HCRU) and Associated Costs (1-Year Follow-Up): Overall

In this study, the overall mean (SD) all-cause HCRU number of visits per patient was highest in the moderate-to-severe treated AD cohort [39.7 (33.9)], followed by the mild-to-moderate treated AD cohort [24.7 (24.9)], and lowest among the untreated or on drugs not included in the treated AD cohorts [17.7 (17.5)]. The mean all-cause annual HCRU gross cost per patient was highest for the moderate-to-severe treated AD cohort (3845.6 USD), followed by the mild-to-moderate treated AD cohort (USD 2673.3), and lowest for the untreated AD cohort (1926.7 USD). The overall all-cause HCRU, inpatient visit costs, and outpatient visit costs contributed majorly to the overall healthcare burden (Table 8).

The overall mean gross annual HCRU costs were higher in the moderate-to-severe treated

Table 5 AD-related healthcare resource utilization and associated costs among patients with AD in Dubai, overall and by encounter type

AD-related HCRU and associated costs (in USD)	Treated AD cohort—mild to moderate	Treated AD cohort—moderate to severe	Untreated or on drugs not included in the treated AD cohort
AD-related overall HCRU, N (patient count)	4580.0	3002.0	5802.0
Number of visits, mean (SD)	4.9 (4.9)	6.5 (5.9)	1.8 (1.7)
Gross cost (in USD), mean (SD)	378.4 (1754.6)	531.5 (2223.8)	144.0 (276.3)
Net cost (in USD), mean (SD)	341.7 (1693.1)	482.7 (2149.2)	129.6 (260.3)
AD-related HCRU by encounter type			
Inpatient visits, N (patient count)	14	12	8
Number of visits, mean (SD)	3.6 (4.1)	4.0 (4.3)	1.0 (0.0)
Gross cost (in USD), mean (SD)	10,502.3 (23,435.2)	11,925.3 (25,167.3)	640.7 (467.5)
Net costs (in USD), mean (SD)	10,228.4 (23,095.7)	11,605.9 (24,813.0)	620.2 (438.6)
Outpatient, N (patient count)	4569.0	2996.0	5767.0
Number of visits, mean (SD)	4.8 (4.9)	6.5 (5.8)	1.8 (1.7)
Gross costs (in USD), mean (SD)	345.2 (822.6)	482.2 (1139.0)	143.4 (275.5)
Net costs (in USD), mean (SD)	309.3 (770.8)	435.1 (1081.0)	129.0 (259.4)
Emergency room visits	38.0	25.0	50.0
Number of visits, mean (SD)	3.1 (1.7)	3.6 (1.6)	1.8 (1.3)
Gross costs (in USD), mean (SD)	243.1 (219.1)	315.0 (230.3)	74.3 (68.3)
Net costs (in USD), mean (SD)	203.9 (174.2)	266.30 (179.1)	64.5 (60.1)
Inpatient asthma subgroup, N (patient count)	2.0	2.0	0
Number of visits, mean (SD)	3.0 (1.4)	3.0 (1.4)	0 (0)
Gross costs (in USD), mean (SD)	7629.1 (3550.9)	7629.1 (3550.9)	0 (0)
Net costs ((in USD), mean (SD)	7049.6 (2731.3)	7049.6 (2731.3)	0 (0)

Table 5 continued

AD-related HCRU and associated costs (in USD)	Treated AD cohort—mild to moderate	Treated AD cohort—moderate to severe	Untreated or on drugs not included in the treated AD cohort
Inpatient allergic rhinitis subgroup, N (patient count)	2.0	2.0	1.0
Number of visits, mean (SD)	2.0 (0)	2.0 (0)	1.0 (0)
Gross costs (in USD), mean (SD)	2796.7 (3283.5)	2796.7 (3283.5)	1041.5 (0)
Net costs (in USD), mean (SD)	2796.7 (3283.5)	2796.7 (3283.5)	1041.5 (0)

AD atopic dermatitis, *CPT* current procedural terminology, *HCPCS* healthcare common procedure coding system, *HCRU* healthcare resource utilization, *SD* standard deviation, *USD* United States dollar

[a]Services: Consultations etc.

[b]Unknown: The discrepant value present in the sum of net cost by activities and total net cost as per e-claims database

AD cohort than in the mild-to-moderate treated AD cohort, including patients hospitalized for comorbid conditions of asthma (3176.5 USD versus 2386.1 USD, respectively) or allergic rhinitis (2781.7 USD versus 2287.8 USD, respectively), thus representing a higher cost burden.

DISCUSSION

This is the first-of-its-kind secondary database analysis of insurance e-claims database wherein patients (insured expatriates) with AD in Dubai (UAE) were evaluated for direct medical costs in terms of HCRU costs, specialties involved in diagnoses of AD, and treatment patterns. Across the cohorts in the study, the mean age (latest available age at the time of data abstraction) of patients was about 29 years. In this study, age- and gender-wise distribution of AD was being evaluated; however, conclusions could not be drawn owing to availability of only 50% of the patients for these variables. Nevertheless, from the available data of 50% of patients, it was observed that the majority (approximately 65%) of the patients belonged to the age group of 18+ years. This finding is consistent with a few global studies that have indicated increased prevalence of AD among adults with an onset after 18 years of age [40–42]. Furthermore, this finding is in line with a 2017 global survey involving 18 countries that indicated an increased prevalence of AD with age, lowest among infants, whereas highest during adulthood, and slightly lower prevalence in adolescents [43, 44]. While a few of the studies had indicated AD to be more prevalent in females than males [35, 45, 46], the data analysis from this study indicated otherwise (male ∼ 60% and female ∼ 40%).

AD is known to coexist with conditions such as bronchial asthma, allergic rhinitis, allergic contact dermatitis, and food allergies [47, 48]; and is also associated with increased risk of bacterial infection [49]. The wide variability of clinical presentation of bacterial infection in AD often overlaps with the inherent clinical characteristics of AD, making its diagnosis even more challenging [49]. One of the previous studies concluded that there are many epidemiologic parallels between asthma and AD, and it is observed that asthma occurs in children with AD later during their childhood [50]. Longitudinal studies have also demonstrated an association between severity of AD and occurrence of asthma and allergic rhinitis in children [51, 52]. Analysis of pre-index period data of the treated patients with AD who were hospitalized showed that 4.5% (n = 38) and 5.5% (n = 16) of

Table 6 HCRU costs associated with AD per patient related to disease severity, overall and by activity type (1 year follow-up)

AD-related HCRU costs (in USD) per patient	Treated AD cohort—mild to moderate	Treated AD cohort—moderate to severe	Untreated or on drugs not included in the treated AD cohort
AD-related healthcare overall gross costs (in USD) by activity type			
Drugs, N (patient count)	3931	2899	3310
Cost, mean (SD)	196.5 (913.0)	256.7 (1166.2)	88.4 (249.1)
CPT, N (patient count)	1323	881	1696
Cost, mean (SD)	197.1 (407.6)	280.1 (624.0)	137.5 (214.2)
HCPCS, N (patient count)	26	18	22
Cost, mean (SD)	538.0 (1946.0)	768.9 (2320.4)	55.2 (132.0)
Services[d], N (patient count)	3222	2133	3357
Cost, mean (SD)	154.9 (1098.7)	202.0 (1347.3)	65.0 (69.4)
Unknown[e], N (patient count)	469	342	253
Cost, mean (SD)	194.4 (2154.9)	245.3 (2518.7)	63.4 (114.6)
Mean (SD) healthcare resource costs (USD) per member (1-year follow-up) for inpatients (by activity type)			
Drugs	2941.3 (6656.2)	3227.2 (6944.8)	107.8 (84.6)
CPT[b]	1623.9 (2301.1)	2009.5 (2441.1)	330.2 (308.7)
HCPCS[c]	1932.7 (4096.3)	1932.7 (4096.3)	183.5 (241.5)
Services[d]	9285.7 (20,920.3)	12,156.8 (23,940.3)	86.0 (53.9)
Unknown[e]	3979.0 (7832.2)	4152.2 (8286.9)	290.81 (323.4)
Mean (SD) healthcare resource costs (USD) per member (1-year follow-up) for emergency visits (by activity type)			
Drugs	76.7 (98.5)	98.0 (109.1)	34.85 (36.4)
CPT[b]	127.9 (109.1)	181.0 (93.3)	52.0 (55.0)
HCPCS[c]	0 (0)	0 (0)	
Services[d]	146.4 (103.4)	178.8 (103.4)	40.57 (31.8)
Unknown[e]	19.0 (26.1)	19.0 (26.1)	2.4 (2.9)
Mean (SD) healthcare resource costs (USD) per member (1-year follow-up) for outpatients (by activity types)			
Drugs	188.4 (665.7)	245.6 (912.7)	88.7 (249.9)
CPT[b]	185.7 (313.9)	263.0 (540.7)	137.5 (214.2)
HCPCS[c]	196.5 (860.7)	298.4 (1079.3)	34.8 (103.4)
Services[d]	130.9 (178.6)	166.9 (208.8)	65.3 (69.7)

Table 6 continued

AD-related HCRU costs (in USD) per patient	Treated AD cohort—mild to moderate	Treated AD cohort—moderate to severe	Untreated or on drugs not included in the treated AD cohort
Unknown[e]	111.3 (968.5)	138.8 (1134.3)	58.8 (100.7)

AD atopic dermatitis, *CPT* current procedural terminology, *HCPCS* healthcare common procedure coding system, *HCRU* healthcare resource utilization, *SD* standard deviation, *USD* United States dollar

[a]The net charge billed by the provider to the payer for the activity

[b]Procedures—medical, surgical, and diagnostic services

[c]Supplies and consumables

[d]Services: consultations etc.

[e]Unknown: the discrepant value present in the sum of net cost by activities and total net cost as per e-claims database

Table 7 Healthcare resource (visits and costs) per member by any infection

HCRU and associated cost (in USD) by infection	Disease-specific HCRU	All-cause HCRU
HCRU visit [mean (SD)]		
Mild to moderate	3.2 (2.7)	4.8 (5.7)
Moderate to severe	3.7 (2.9)	7.4 (7.7)
Untreated or on drugs not included in the treated AD cohorts	1.6 (1.4)	3.2 (3.0)
HCRU cost [mean (SD)], in USD		
Mild to moderate		
Gross cost	311.5 (2501.2)	422.0 (1763.6)
Patient share	25.3 (41.3)	36.2 (113.8)
Net cost	289.1 (2456.6)	381.2 (1681.9)
Moderate to severe		
Gross cost	386.6 (2957.3)	643.9 (2408.1)
Patient share	29.9 (47.6)	53.3 (104.0)
Net cost	360.2 (2905.1)	584.8 (2307.9)
Untreated or on drugs not included in the treated AD cohorts		
Gross cost	130.1 (234.4)	309.0 (864.8)
Patient share	15.2 (24.2)	27.7 (59.0)
Net cost	118.9 (223.2)	274.4 (773.5)

AD atopic dermatitis, *HCRU* healthcare resource utilization, *SD* standard deviation, *USD* United States dollar

patients had asthma among mild-to-moderate treated AD patients and moderate-to-severe treated AD patients, respectively.

In this study, among mild-to-moderate treated AD cohorts, the most commonly prescribed drug class was TCS, followed by antihistamines and TCI, and this trend is in line with a similar study conducted in Germany [46]. The long-term management of mild-to-moderate AD is based on recent guidelines and efficacy study;

Table 8 All-cause healthcare resource utilization and associated costs among patients with AD in Dubai

All-cause HCRU and associated costs (in USD)	Treated AD cohort—mild to moderate	Treated AD cohort—moderate to severe	Untreated or on drugs not included in the treated AD cohort
All-cause, overall HCRU, N (patient count)	10,134	3515	10,799
Number of visits, mean (SD)	24.7 (24.9)	39.7 (33.9)	17.7 (17.5)
Gross cost, mean (SD)	2673.3 (22,062.0)	3845.6 (6319.9)	1926.7 (3884.0)
Net cost, mean (SD)	2209.6 (4294.0)	3464.9 (5809.9)	1725.2 (3538.1)
All-cause HCRU by encounter type			
Inpatient visits, N (patient count)	871	313	962.0
Number of visits, mean (SD)	1.8 (1.5)	2.6 (2.0)	1.5 (3.6)
Gross cost, mean (SD)	3470.3 (6324.5)	4531.2 (8228.9)	2777.3 (5489.7)
Net costs, mean (SD)	3218.7 (6028.0)	4269.8 (7940.9)	2537.2 (4867.8)
Outpatient, N (patient count)	10,129.0	3512.0	10,788.0
Number of visits, mean (SD)	24.0 (24.2)	38.6 (32.9)	17.0 (16.4)
Gross costs, mean (SD)	2309.0 (21,878.2)	3341.3 (5089.9)	1617.1 (2916.8)
Net costs, mean (SD)	1877.1 (3350.3)	3000.4 (4682.6)	1445.3 (2704.4)
Emergency room visits	1547.0	576.0	1971.0
Number of visits, mean (SD)	3.8 (5.8)	5.7 (8.1)	3.0 (3.9)
Gross costs, mean (SD)	440.0 (602.0)	631.4 (747.4)	349.3 (913.8)
Net costs, mean (SD)	370.3 (505.3)	530.7 (623.8)	303.0 (887.4)
Asthma subgroup, N (patient count)	74	26	55
Number of visits, mean (SD)	1.7	2.4	1.3
Net cost, mean (SD)	2002.7 (2871.8)	2930.9 (3521.0)	1769.0 (2035.9)
Allergic rhinitis subgroup, N (patient count)	17	6	12
Number of visits, mean (SD)	1.4	2.0	1.1
Net cost, mean (SD)	2060.1 (2931.5)	2727.0 (2669.0)	442.7 (730.0)

Table 8 continued

All-cause HCRU and associated costs (in USD)	Treated AD cohort—mild to moderate	Treated AD cohort—moderate to severe	Untreated or on drugs not included in the treated AD cohort
All-cause mean (SD) healthcare costs (in USD) by activity type			
Drugs, N (patient count)	9994	3502	10,296
Mean (SD)	695.4 (1975.2)	1,167.3 (2939.6)	489.0 (1344.8)
CPT, N (patient count)	9198	3215	9948
Mean (SD)	926.0 (2252.9)	1352.2 (2747.9)	761.8 (2091.7)
HCPCS, N (patient count)	1,050	386	1227
Mean (SD)	421.5 (1188.5)	539.6 (1595.6)	412.7 (1627.7)
Services[a], N (patient count)	9836	3439	10,600
Mean (SD)	581.0 (1143.9)	919.2 (1644.9)	454.1 (879.5)
DRG, N (patient count)	17	4	14
Mean (SD)	0 (0)	0 (0)	0 (0)
Unknown[b], N (patient count)	4966	1833	5176
Mean (SD)	199.8 (1555.8)	279.3 (2009.8)	135.8 (931.5)

AD atopic dermatitis, *CPT* current procedural terminology, *DRG* diagnosis-related group, *HCPCS* healthcare common procedure coding system, *HCRU* healthcare resource utilization, *SD* standard deviation, *USD* United States dollar
[a]Services: consultations, etc.
[b]Unknown: the discrepant value present in the sum of net cost by activities and total net cost as per e-claims database

thus, the management includes proactive therapy with TCS and TCIs (tacrolimus) [1, 53]. This study indicated a switch pattern that is in line with previous studies, which showed that switch between TCIs and TCSs is common, depending upon the disease severity and symptom control conferred by the treatment [54]. The switch-overs were comparatively higher from first-line TCS to second-line TCI among patients of the mild-to-moderate group along with addition of TCI as first add-on to an ongoing TCS. From the very limited available data on switch pattern among moderate-to-severe treated AD patients, it was noted that three patients switched from the first-line corticosteroids to biologics, and one patient had an addition of corticosteroid to an ongoing biologics treatment.

With regard to antihistamine use, the clinical guidelines by American Academy of Dermatology Association recommends limited use of antihistamines, especially topical antihistamines due to absorption and risk of contact dermatitis [1]. On the contrary, a recent study on German population showed that 23.5% of patients used antihistamines [46]. Furthermore, this study also indicated substantially higher usage of antihistamines in Dubai: 52% of mild-to-moderate treated AD patients had 7689 (47%) antihistamines claims, and 65% of moderate-to-severe treated AD patients had 4227 (45%) antihistamines claims.

An earlier claims database study conducted in the USA indicated increased HCRU among patients with moderate-to-severe AD compared with those with mild-to-moderate disease [55]. An observational cohort study from the

Netherlands reported a significant increase in direct cost due to systemic immunosuppressive treatment use among patients with moderate-to-severe AD [56]. Although this study revealed of highest HCRU in the moderate-to-severe treated AD cohort, the claims made for immunosuppressive agents were very low in the moderate-to-severe cohort. This study indicated that main drivers of direct medical cost were hospitalizations, outpatient visits, supplies, and consumables, followed by procedures and medications.

A 2019 review article on the socioeconomics of AD concluded that AD incurs substantial direct cost among patients with AD, including for their family and payers as well [57, 58]. A 2013 study on burden of skin disease indicated that, among various skin diseases, total burden of dermatitis (atopic, contact, and seborrheic dermatitis) in terms of disability-adjusted life years was highest at 0.38%, followed by acne vulgaris (0.29%), psoriasis (0.19%), urticaria (0.19%), etc. [58]. An earlier 2004 US study on economic burden of skin disease showed a higher annual cost among patients with AD (4.228 billion USD) than patients with psoriasis (3.658 billion USD) [59]. The increased direct AD costs has been shown by various studies: one such 2013 US study showed annual direct cost to be between 252 USD million and 314 USD million [60], and a 2015 Korean study estimated per patient annual cost of 2,646,372 Korean Won (KRW) (2088 USD; exchange rate as of 18 May 2022) [61]. A recent retrospective US database study reported a significant increase in direct cost among adult patients with AD: 938 USD in 2016 and 1466 USD in 2017 [34, 60].

This study reported per-patient gross cost of 531.5 USD, 378.48 USD, and 144.04 USD among moderate-to-severe treated AD cohort, mild-to-moderate treated AD, and untreated AD cohort, respectively. Thus, the higher overall annual HCRU-associated costs were reported by the moderate-to-severe treated AD cohort, followed by the mild-to-moderate treated AD cohort. When all-cause cost was considered, the moderate-to-severe treated AD cohort had higher cost than the mild-to-moderate treated AD cohort even for patients

hospitalized with asthma (3176.5 USD versus 2386.1 USD, respectively) or allergic rhinitis (2781.7 USD versus 2287.8 USD, respectively). Thus, the study indicated that asthma and allergic rhinitis are important drivers of overall HCRU and cost burden when all causes are considered. However, this result could not be interpreted for AD-specific HCRU burden because of limited data available for analysis. The available results indicate higher HCRU associated with moderate-to-severe disease than mild-to-moderate disease, and thus, an early intervention could reduce the overall HCRU burden.

Overall, among AD-diagnosed patients who had *Staphylococcus* infection, the mean HCRU and associated costs had highest burden on the mild-to-moderate AD-treated patients (7.0 and 10,313.9 USD, respectively), followed by moderate-to-severe AD-treated patients (6.0 and 8319.9 USD, respectively), and lowest for the untreated AD cohort (1.0 visit and 97.2 USD, respectively). However, among AD-diagnosed patients with any infection, the HCRU and associated cost was highest for moderate-to-severe treated AD patients than mild-to-moderate treated AD patients (3.7; 386.6 USD versus 3.2; 311.5 USD, respectively).

There are certain inherent limitations associated with the study based on e-claims database that can impact the study interpretation. The study sample covered only private insured expatriate population of Dubai (UAE), mostly representative of the population who were from a different country of origin but settled in Dubai either temporarily or permanently for an extended period. Thus, this database does not consider the local population covered by public funding, who were not a part of Dubai Private Insurance. Also, a filled prescription e-claim is not indicative of the medication being consumed or taken as prescribed and thus can be used only as a surrogate measures for AD severity rather than an objective clinical measure. As a general guidance for management of AD, most of the patients irrespective of the AD severity may be using nonmedicated topical therapy (such as emollients) that are not recorded in this database. The patients considered under

untreated or on drugs not included in the treated AD cohorts may be on mild disease using emollients or other medication for which no prescription was filled or allocation in severity, thus leading to difficulty in establishment of severity of AD as mild and moderate. The variability in treatment pattern across providers cannot be ruled out and may introduce information bias. Another limitation included the availability of biologics for AD treatment in Dubai (UAE). The e-claims data may be subject to disease-coding inaccuracies, attributable to inaccurately coded or included as rule-out criteria rather than "actual disease," leading to misclassification bias. Furthermore, information pertaining to certain clinical and disease-specific parameters is not readily available in the e-claims database. Additionally, the DRWD database only provides information that a specific medication or a service was availed but does not allow one-to-one mapping between diagnosis and medication/procedure/consumables. Thus, the overlap of patients between the mild-to-moderate and the moderate-to-severe treated AD cohort cannot be ruled out as severity categorization was based on treatment prescribed. Furthermore, for patients aged < 1 year, a 12-month pre-index period was not applicable, and therefore, they were not considered in the study for HCRU, treatment pattern patient characteristics analysis. Moreover, it was noted during the data analysis that the age and gender data were available for only about 50% of the patients, hence limiting the interpretation of the results in relation to patient demographics and disease severity evaluation. Finally, the study evaluated only the economic burden in terms of direct healthcare costs without considering the indirect costs (work productivity and quality of life) in the evaluation of the economic burden of AD. Some of these challenges can be overcome in future by updating database for relevant variables, as appropriate. Despite of the limitations, the DRWD is a rich source of information that has provided insights into direct cost utilization and treatment patterns based on specialties involved.

CONCLUSIONS

This study indicated AD to be a common skin disease with a prevalence rate of 4–5% in Dubai (UAE), with the majority of patients (about 90%) being treated by specialists. However, there is a significant underuse of newer innovative therapies (including biologics). Also, disease severity (moderate-to-severe AD) was associated with high direct medical cost, which could be controlled by early intervention. Furthermore, AD treatment choice could focus on major direct HCRU cost contributors such as hospitalizations, comorbid conditions, and infections.

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Compliance with Ethics Guidelines. This study was based on secondary, de-identified data which comply with the Health Insurance Portability and Accountability Act (HIPAA). Ethics committee approval was not required for this study, as it did not involve the collection, use, or transmittal of individual identifiable data. DRWD contains anonymized structured insurance e-claims data of the patients. Patients' identity or medical records were not disclosed for the purposes of this study, except where disclosure was allowed as per applicable law. The study conformed to the ethical principles of the Declaration of Helsinki of 1964 and its later amendments.

Data Availability. All data generated or analyzed during this study are included in this published article or in the supplementary material.

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