Clinical, Cosmetic and Investigational Dermatology

Dovepress
Taylor & Francis Group

Open Access Full Text Article

ORIGINAL RESEARCH

Global, Regional, and National Burden of Alopecia Areata in Children and Adolescents Aged 0-19 years from 1990 to 2021 and Projection to 2040

Hongzheng Lu[1], Jinbo Li[2], Ke Ma[3,4], Lin Li[1], Shengchun Wang[1], TingTing Wang[1], Bin Zhang[5]

[1]Department of Dermatology, Children's Hospital Affiliated of Zhengzhou University, Henan Children's Hospital, Zhengzhou Children's Hospital, Zhengzhou, People's Republic of China; [2]School of Public Health, Shanxi Medical University, Taiyuan, People's Republic of China; [3]Department of Clinical Research, Nobelpharma Co. Ltd, Tokyo, Japan; [4]Department of Pharmacology, School of Life Science and Biopharmaceutics, Shenyang Pharmaceutical University, Shenyang, People's Republic of China; [5]Department of Dermatology, Beijing Children's Hospital, Capital Medical University, National Center for Children's Health, Key Laboratory of Major Diseases in Children, Ministry of Education, Beijing, People's Republic of China

Correspondence: Bin Zhang, Department of Dermatology, Beijing Children's Hospital, Capital Medical University, National Center for Children's Health, Key Laboratory of Major Diseases in Children, Ministry of Education, No. 56 Nanlishi Road, Xicheng District, Beijing, 100045, People's Republic of China, Tel +861059616392, Fax +861059718700, Email dr.binzhang@163.com; Jinbo Li, School of Public Health, Shanxi Medical University, 56 Xinjian South Road, Taiyuan, 030001, People's Republic of China, Email lijinbo@sxmu.edu.cn

Background: Global epidemiological patterns of alopecia areata in pediatric populations remain inadequately characterized. We evaluated the disease burden and trends among children and adolescents aged 0–19 years across 204 countries and territories from 1990 to 2021 and projected the disease development from 2022 to 2040.

Methods: Using Global Burden of Disease (GBD) 2021 data, we analyzed incidence, prevalence, and disability-adjusted life years (DALYs), stratified by sex, age, and Sociodemographic Index (SDI). Temporal trends were quantified via estimated annual percentage changes (EAPC) in age-standardized rates. The Bayesian age cohort model was used to predict prevalent cases trend from 2022 to 2040.

Results: In 2021, global prevalent cases increased by 15.79% (1990–2021), yet age-standardized incidence (ASIR), prevalence (ASPR), and DALY rates (ASDR) declined significantly (EAPC range: −0.092 to −0.099). Females consistently bore 75% higher burden than males. Disease metrics escalated with age, peaking in the 15–19 age subgroup. Low-SDI group exhibited rising ASIR/ASPR/ASDR (EAPC up to 0.050), contrasting declines in higher-SDI areas. High-income North America recorded the highest ASPR (145.84/100,000) but the most rapidly decline (EAPC=−0.251), while Central Sub-Saharan Africa showed the steepest increases. India reported the highest national prevalent cases (420,913) in 2021. The disease burden of alopecia areata among children and adolescents aged 0–19 years worldwide and in India will tend to be stable from 2022 to 2040, while the disease burden in China will rise, and in the United States of America, it will continue to decline.

Conclusion: Despite a decrease in the relative burden, the absolute number of alopecia areata cases rose globally. Critical disparities persist among females, adolescents (15–19 years), and low-SDI populations—particularly in Central Sub-Saharan Africa. Targeted interventions for these vulnerable groups are urgently needed.

Keywords: alopecia areata, global burden of disease, incidence, prevalence, disability-adjusted life years, children and adolescents

Introduction

Alopecia areata (AA) is a non-scarring autoimmune disorder characterized by hair loss. While its precise etiology remains incompletely elucidated, genetic predisposition, environmental triggers, and immune dysregulation are implicated. The global prevalence of alopecia areata is approximately 0.1%-2.1%, with a lifetime risk nearing 2%. The prevalence of children and adolescents is estimated at 1.83%.[1–4] Children and adolescents with alopecia areata develop rapidly and are prone to developing alopecia areata totalis and alopecia universalis, and early onset of these conditions is clearly linked to poor treatment results.[5] Although alopecia areata itself is not serious enough to threaten life, the sudden onset of hair loss in alopecia areata seriously affects the appearance and image of children and adolescents, increasing

https://doi.org/10.2147/CCID.S582775
Received: 19 November 2025
Accepted: 29 January 2026
Published: 6 February 2026

their vulnerability to ridicule, isolation, and even school bullying from peers, resulting in anxiety, depression, inferiority complexes, learning and social difficulties.[6–8] Severe alopecia areata requires long-term systemic use of medication, and its side effects may affect the growth and development of children and adolescents. Alopecia areata among pediatric patients have an increased risk of developing autoimmune disorders and metabolic disorders, such as atopic dermatitis, vitiligo, psoriasis, obesity, hyperlipidemia, diabetes mellitus and metabolic syndrome.[9–11] Among children and adolescents, alopecia areata is a substantial public health problem.

Although studies have reported the disease burden of alopecia areata in all age groups,[12–14] children are not scaled-down adults, and the disease burden and future projected trends in the pediatric population still lack sufficient attention. Our investigation pioneers the use of the Global Burden of Disease(GBD) 2021 database to conduct a comprehensive global assessment of alopecia areata incidence, prevalence, and disability-adjusted life years (DALYs) specifically among individuals aged 0–19 years. We analyzed trends stratified by sex, age group, and Sociodemographic Index (SDI), exploring pediatric-specific patterns and SDI-disease burden relationships. We used the Bayesian age cohort (BAPC) model to predict the prevalence trend from 2022 to 2040. This analysis provides novel evidence to inform future epidemiological studies, preventive strategies, and health policy formulation.

Methods

Study Population and Data Collection

This study focused on the disease burden of alopecia areata in children and adolescents aged 0–19 years. Data were sourced from GBD 2021.[15] The GBD 2021 database provides exhaustive estimates for 371 diseases and injuries across 204 countries and territories, categorized into 21 GBD regions, spanning 1990 to 2021. Utilizing available data, we retrieved figures for alopecia areata case counts, prevalence, incidence, and DALYs in the target age group (<20 years), along with corresponding demographic and geographic variables (age, sex, SDI, region, country). Our analysis relies on the GBD study's modeled estimates. It is important to note that the accuracy and precision of these estimates are contingent on the availability and quality of underlying input data. Estimates for low-income countries and regions with weak health information systems are associated with higher uncertainty due to reliance on modeling and sparser primary data. This inherent characteristic of global comparative estimates should be considered when interpreting this study's findings.

Definitions

DALY: This metric quantifies overall population health loss, combining Years of Life Lost (YLLs) due to premature mortality and Years Lived with Disability (YLDs) attributable to alopecia areata.

Age Stratification: the study cohort (<20 years) was divided into four subgroups: <5 years, 5–9 years, 10–14 years, and 15–19 years.[15,16]

Socio-demographic Index (SDI): Representing socio-demographic development (scale 0–1), SDI integrates three components: lag-distributed income (LDI) per capita, mean educational attainment for individuals aged ≥15 years (EDU15+), and the total fertility rate for women under 25 (TFU25). Countries were classified into five SDI quintiles: low, low-middle, middle, high-middle, and high. Higher SDI typically correlates with better population health outcomes.

Data Extraction and Uncertainty: The GBD Data Exchange tool provided location-, sex-, and age-specific data for incidence, prevalence, and DALY data. The 95% uncertainty interval (UI) for each estimate, derived from the 2.5th and 97.5th percentiles of 1000 posterior draws, reflects modeling uncertainty.

Case Definition: AA cases were identified using ICD-10 codes L63-L63.9 (skin or subcutaneous diseases) within the GBD 2021 cause list.[15,16]

Reporting Standards: This study adheres to the GATHER (Guidelines for Accurate and Transparent Health Estimates Reporting) statement (Supplementary Table S1).

Statistical Analysis

Descriptive statistics characterized the overall alopecia areata burden of globally and across strata (age, sex, SDI, location), using age-standardized rates (ASRs). Global, regional, and national prevalence and YLDs for pediatric alopecia areata were calculated and reported with 95% UIs. Rates are expressed per 100,000 population. Temporal trends were assessed using Estimated Annual Percentage Change (EAPC): An upward trend in the ASR was indicated if both the EAPC and the lower limit of its 95% confidence interval (CI) were positive. A downward trend was indicated if the upper limit of the EAPC's 95% CI was negative. EAPCs were computed for Age-Standardized Incidence Rate (ASIR), the Age-Standardized Prevalence Rate (ASPR), and Age-Standardized DALY Rate (ASDR) to quantify changes in the burden of alopecia areata over time. Findings are presented for all GBD regions and 204 countries/territories, contextualized by their SDI values.[15–17] To predict the future burden of alopecia areata in adolescent under 20 years of age, we used the Bayesian Age-Period-Cohort (BAPC) model to project the future burden from 2022 to 2040. This model operates within a Bayesian framework, extending the traditional Generalized Linear Model (GLM) by simultaneously accounting for the independent effects of age, period, and cohort. It assumes that the data follow a Poisson distribution and utilizes prior distributions, such as a Random Walk, to smooth the estimates for these three dimensions, thus enhancing the stability of the projections. A key advantage of the BAPC model is its implementation of the Integrated Nested Laplace Approximation (INLA) algorithm, which efficiently approximates the posterior marginal distributions and enables more accurate estimation of unknown parameters than conventional methods. For model validation, the "retro=TRUE" argument was specified to generate retrospective predictions for the past 25 years within the observation period, enabling in-sample accuracy assessment and ensuring the model's robustness before extrapolating future trends. This well-validated approach has been extensively applied in descriptive epidemiology, providing a reliable foundation for forecasting the incidence and mortality of various health conditions.

Results

Global Trends

Alopecia areata burden in children and adolescents exhibited a dual global pattern: increasing absolute burden alongside decreasing relative burden. Worldwide prevalent cases rose from 2,112,572 (95% UI: 1,985,970–2,239,288) in 1990 to 2,446,132 (95% UI: 2,297,538–2,591,574) in 2021, a 15.79% increase (Table 1). Incident cases increased by 15.81%, from 3,879,078 (95% UI: 3,632,198–4,123,095) to 4,492,409 (95% UI: 4,206,530–4,769,159) (Supplementary Table S2). DALYs reached 81,979 (95% UI: 53,440–118,068) in 2021, marking a 15.99% rise from 70,677 (95% UI: 46,053–-101,658) in 1990 (Table 1). Conversely, the ASPR declined from 93.23 (95% UI: 84.20–102.63) to 90.77 (95% UI: 82.06–99.80) per 100,000 (EAPC = −0.099). The ASDR decreased from 3.12 (95% UI: 2.01–4.56) to 3.04 (95% UI: 1.97–4.41) per 100,000 (EAPC = −0.092) (Table 1). Collectively, all ASRs (ASPR, ASIR, ASDR) demonstrated consistent declines over 32 years (Table 1, Supplementary Table S2 and Figure 1). Compared with the total number of alopecia areata cases, the proportion of prevalent cases in children and adolescents has been decreasing, from 18.33% in 1990 to 13.96% in 2021 (Supplementary Figure S1).

Sex-Specific Burden Trends

From 1990 to 2021, incident, prevalent, and DALY cases of alopecia areata among children and adolescents increased globally for both males and females, with females consistently exhibiting higher case numbers than males (Table 1, Supplementary Table S2 and Figure 1). Global prevalent cases among pediatric females rose by 15.40%, from 1,319,692 (95% UI: 1,239,904–1,399,393) to 1,522,863 (95% UI: 1,429,639–1,617,120) (Table 1). While ASIR, ASPR, and ASDR declined for both sexes in 2021, the improvement was more pronounced in males. Female rates substantially exceeded male rates: ASIR (213.65 vs 122.30 per 100,000), ASPR (116.52 vs 66.51 per 100,000), and ASDR (3.90 vs 2.23 per 100,000), representing approximately 175% of the male burden across all metrics (Table 1 and Supplementary Table S2).

https://doi.org/10.2147/CCID.S582775

Table 1 Age-Standardized Prevalence and DALYs of Alopecia Areata Among Children and Adolescents Aged 0–19 years Between 1990 and 2021 at the Global and Regional Levels

Characteristics	Prevalence						DALYs					
	Cases in 1990 (95% UI)	Age-Standardized RATE in 1990 (Per 100,000) (95% UI)	Cases in 2021 (95% UI)	Age-Standardized Rate in 2021 (Per 100,000) (95% UI)	Percentage Change (%)	EAPC (95% CI)	Cases in 1990 (95% UI)	Age-Standardized Rate in 1990 (Per 100,000) (95% UI)	Cases in 2021 (95% UI)	Age-Standardized Rate in 2021 (Per 100,000) (95% UI)	Percentage Change (%)	EAPC (95% CI)
Global	2112572 (1985970–2239288)	93.23 (84.20–102.63)	2446132 (2297538–2591574)	90.77 (82.06–99.80)	15.79	−0.099 (−0.109 to −0.089)	70677 (46053–101658)	3.12 (2.01–4.56)	81979 (53440–118068)	3.04 (1.97–4.41)	15.99	−0.092 (−0.103 to −0.082)
Sex												
Female	1319692 (1239904–1399393)	119.12 (107.54–130.98)	1522863 (1429639–1617120)	116.52 (105.05–128.01)	15.40	−0.090 (−0.099 to −0.082)	44122 (28824–63505)	3.98 (2.56–5.87)	50980 (33223–73173)	3.90 (2.52–5.67)	15.54	−0.085 (−0.094 to −0.075)
Male	792880 (743109–839622)	68.48 (61.68–75.43)	923269 (866773–979090)	66.51 (60.04–73.28)	16.44	−0.095 (−0.105 to −0.085)	26554 (17207–38201)	2.29 (1.48–3.33)	30999 (20172–44931)	2.23 (1.43–3.26)	16.74	−0.088 (−0.098 to −0.077)
Age												
<5	253413 (231490–275233)	40.88 (37.34–44.40)	271741 (247910–294945)	41.29 (37.67–44.81)	7.23	−0.024 (−0.066 to 0.018)	8493 (5549–12446)	1.37 (0.90–2.01)	9156 (5913–13339)	1.39 (0.90–2.03)	7.80	−0.013 (−0.056 to 0.031)
5 to 9	454272 (411721–499849)	77.85 (70.56–85.66)	523942 (474716–576884)	76.26 (69.09–83.96)	15.34	−0.077 (−0.086 to −0.067)	15249 (9738–22364)	2.61 (1.67–3.83)	17635 (11250–25286)	2.57 (1.64–3.68)	15.65	−0.067 (−0.077 to −0.057)
10 to 14	525650 (473195–576923)	98.13 (88.33–107.70)	638665 (575789–701976)	95.80 (86.37–105.30)	21.50	−0.089 (−0.096 to −0.083)	17630 (11479–25755)	3.29 (2.14–4.81)	21396 (14049–31110)	3.21 (2.11–4.67)	21.36	−0.085 (−0.091 to −0.078)
15 to 19	879237 (791428–973570)	169.27 (152.37–187.43)	1011783 (912707–1116256)	162.15 (146.27–178.89)	15.08	−0.140 (−0.148 to −0.131)	29305 (18720–42740)	5.64 (3.60–8.23)	33793 (21972–48971)	5.42 (3.52–7.85)	15.31	−0.135 (−0.143 to −0.127)
SDI												
Low SDI	217490 (204172–230150)	83.44 (75.40–91.78)	483756 (454984–511719)	84.19 (76.02–92.69)	122.43	0.030 (0.027 to 0.034)	7226 (4677–10405)	2.77 (1.76–4.03)	16133 (10494–23301)	2.81 (1.80–4.10)	123.26	0.050 (0.044 to 0.055)
Low-middle SDI	481731 (453144–509772)	84.26 (75.95–92.89)	659579 (618570–698163)	84.06 (75.75–92.68)	36.92	−0.008 (−0.017 to −0.000)	16028 (10236–23158)	2.80 (1.80–4.13)	22101 (14246–31493)	2.82 (1.79–4.08)	37.89	0.008 (−0.000 to 0.017)
Middle SDI	739782 (695071–787880)	94.58 (85.19–104.44)	722934 (678016–768307)	93.29 (84.26–102.69)	−2.28	−0.059 (−0.069 to −0.049)	24779 (16299–35597)	3.17 (2.04–4.62)	24259 (15920–34785)	3.13 (2.02–4.56)	−2.10	−0.050 (−0.060 to −0.040)
High-middle SDI	370928 (347737–396290)	96.06 (86.29–106.33)	300777 (282510–320223)	96.12 (86.46–106.32)	−18.91	−0.019 (−0.028 to −0.011)	12481 (8060–17942)	3.23 (2.06–4.74)	10133 (6667–14509)	3.24 (2.06–4.79)	−18.81	−0.013 (−0.022 to −0.005)
High SDI	300780 (282356–318585)	114.44 (103.65–125.66)	277195 (260907–293867)	113.28 (102.61–124.30)	−7.84	−0.052 (−0.081 to −0.023)	10101 (6587–14592)	3.84 (2.46–5.66)	9290 (5996–13487)	3.80 (2.43–5.57)	−8.03	−0.056 (−0.084 to −0.028)
Region												
Andean Latin America	16809 (15747–17925)	89.56 (79.99–99.58)	21423 (20065–22837)	89.06 (79.54–98.96)	27.45	−0.026 (−0.029 to −0.022)	565 (347–830)	3.01 (1.70–4.72)	715 (444–1045)	2.97 (1.73–4.61)	26.58	−0.022 (−0.035 to −0.009)
Australasia	7370 (6886–7880)	111.57 (99.99–123.90)	8685 (8117–9269)	111.76 (100.16–124.11)	17.85	−0.003 (−0.008 to 0.003)	247 (150–369)	3.75 (2.09–5.99)	292 (175–448)	3.76 (2.12–6.06)	18.23	−0.003 (−0.018 to 0.011)
Caribbean	13764 (12878–14667)	89.66 (80.08–99.69)	14064 (13160–14987)	89.56 (79.98–99.54)	2.18	−0.014 (−0.018 to −0.011)	461 (293–682)	3.00 (1.85–4.57)	469 (303–678)	2.99 (1.80–4.52)	1.74	−0.020 (−0.028 to −0.013)

Central Asia	27430 (25717–29267)	89.49 (79.93–99.47)	29879 (28051–31876)	88.97 (79.46–98.86)	8.93	−0.045 (−0.054 to −0.035)	920 (581–1358)	3.00 (1.84–4.64)	1005 (656–1500)	2.99 (1.82–4.61)	9.26	−0.041 (−0.053 to −0.028)
Central Europe	36798 (34476–39156)	89.81 (80.62–99.32)	21962 (20580–23368)	89.56 (80.40–99.03)	−40.32	−0.025 (−0.032 to −0.018)	1238 (795–1806)	3.02 (1.90–4.50)	736 (470–1069)	3.00 (1.88–4.42)	−40.56	−0.022 (−0.031 to −0.013)
Central Latin America	73886 (69348–78656)	89.93 (80.80–99.64)	80310 (75189–85577)	90.00 (80.87–99.66)	8.69	−0.005 (−0.009 to −0.001)	2476 (1625–3587)	3.01 (1.90–4.42)	2689 (1697–3908)	3.01 (1.88–4.48)	8.57	0.001 (−0.005 to 0.007)
Central Sub-Saharan Africa	24483 (23022–26071)	85.05 (76.03–94.54)	61231 (57469–65149)	85.57 (76.49–95.10)	150.10	0.019 (0.017 to 0.021)	813 (518–1226)	2.82 (1.62–4.47)	2044 (1299–3078)	2.85 (1.66–4.62)	151.30	0.045 (0.034 to 0.056)
East Asia	477061 (445125–512562)	97.55 (87.05–108.47)	343765 (321437–368018)	98.03 (87.48–108.93)	−27.94	−0.033 (−0.050 to −0.016)	16050 (10535–23136)	3.28 (2.08–4.84)	11614 (7581–16795)	3.31 (2.09–4.89)	−27.64	−0.020 (−0.037 to −0.004)
Eastern Europe	61789 (58097–66006)	90.38 (80.71–100.24)	42978 (40459–45924)	90.20 (80.50–100.03)	−30.44	−0.028 (−0.047 to −0.009)	2074 (1357–3015)	3.03 (1.94–4.53)	1444 (946–2068)	3.03 (1.95–4.55)	−30.39	−0.020 (−0.038 to −0.001)
Eastern Sub-Saharan Africa	88674 (83382–94168)	85.65 (77.05–94.65)	193617 (181425–205601)	86.07 (77.29–95.14)	118.35	0.019 (0.018 to 0.019)	2949 (1899–4235)	2.85 (1.78–4.21)	6472 (4168–9447)	2.88 (1.80–4.25)	119.48	0.041 (0.036 to 0.047)
High-income Asia Pacific	61634 (57377–65898)	111.10 (99.58–122.90)	36776 (34282–39190)	111.35 (99.79–123.17)	−40.33	0.009 (0.003 to 0.015)	2072 (1345–3017)	3.74 (2.33–5.56)	1235 (796–1785)	3.74 (2.36–5.62)	−40.41	0.010 (0.002 to 0.019)
High-income North America	114193 (107644–120796)	136.55 (124.11–149.85)	122222 (115145–129430)	128.53 (116.79–140.92)	7.03	−0.251 (−0.328 to −0.175)	3831 (2463–5555)	4.58 (2.93–6.74)	4088 (2654–5958)	4.30 (2.74–6.35)	6.71	−0.258 (−0.335 to −0.180)
North Africa and Middle East	139971 (131293–148646)	81.28 (72.84–89.81)	194652 (182533–206840)	81.72 (73.23–90.41)	39.07	0.006 (0.000 to 0.012)	4692 (2982–6809)	2.72 (1.72–4.05)	6522 (4211–9383)	2.74 (1.72–4.12)	39.01	0.011 (0.004 to 0.018)
Oceania	3334 (3122–3547)	102.34 (91.38–113.69)	6298 (5898–6698)	102.11 (91.19–113.45)	88.89	−0.011 (−0.014 to −0.008)	111 (69–166)	3.41 (1.98–5.34)	212 (132–310)	3.43 (1.94–5.42)	90.43	−0.000 (−0.012 to 0.012)
South Asia	414678 (389435–441058)	78.87 (70.80–87.47)	567916 (531452–604306)	79.08 (70.96–87.74)	36.95	0.015 (0.009 to 0.021)	13762 (8889–19841)	2.62 (1.67–3.87)	19006 (12275–27145)	2.65 (1.69–3.85)	38.10	0.034 (0.028 to 0.041)
Southeast Asia	244546 (228914–259275)	110.85 (99.46–122.35)	262463 (244827–278558)	110.67 (99.37–122.23)	7.33	−0.008 (−0.010 to −0.006)	8188 (5251–11914)	3.71 (2.35–5.46)	8808 (5642–12764)	3.71 (2.34–5.46)	7.57	0.005 (0.000 to 0.010)
Southern Latin America	21842 (20399–23356)	111.77 (99.77–124.52)	23107 (21547–24724)	112.41 (100.34–125.25)	5.79	0.002 (−0.007 to 0.011)	739 (453–1074)	3.78 (2.19–5.98)	774 (490–1139)	3.77 (2.26–5.86)	4.77	−0.007 (−0.020 to 0.005)
Southern Sub-Saharan Africa	22561 (21211–23922)	86.21 (77.54–95.12)	27221 (25581–28857)	85.91 (77.27–94.84)	20.66	−0.019 (−0.023 to −0.014)	753 (478–1116)	2.88 (1.79–4.32)	912 (578–1314)	2.88 (1.75–4.34)	20.97	−0.013 (−0.019 to −0.006)
Tropical Latin America	63593 (59821–67952)	90.52 (80.65–100.46)	61403 (57653–65701)	89.86 (80.08–99.70)	−3.44	−0.023 (−0.028 to −0.019)	2119 (1379–3096)	3.02 (1.91–4.49)	2048 (1336–2979)	3.00 (1.89–4.48)	−3.35	−0.012 (−0.018 to −0.006)
Western Europe	112439 (105217–120220)	107.14 (96.28–118.06)	103433 (96917–110404)	107.41 (96.47–118.38)	−8.01	0.003 (−0.001 to 0.007)	3771 (2455–5443)	3.60 (2.29–5.34)	3466 (2219–4974)	3.60 (2.29–5.32)	−8.08	0.001 (−0.004 to 0.005)
Western Sub-Saharan Africa	85716 (80843–90779)	85.88 (77.15–94.81)	222727 (209834–235662)	85.95 (77.24–94.86)	159.84	0.006 (−0.004 to 0.017)	2847 (1830–4091)	2.85 (1.80–4.18)	7431 (4841–10713)	2.87 (1.82–4.20)	161.02	0.025 (0.012 to 0.037)

Abbreviations: DALYs, disability-adjusted life-years; SDI, socio-demographic index.

https://doi.org/10.2147/CCID.S582775

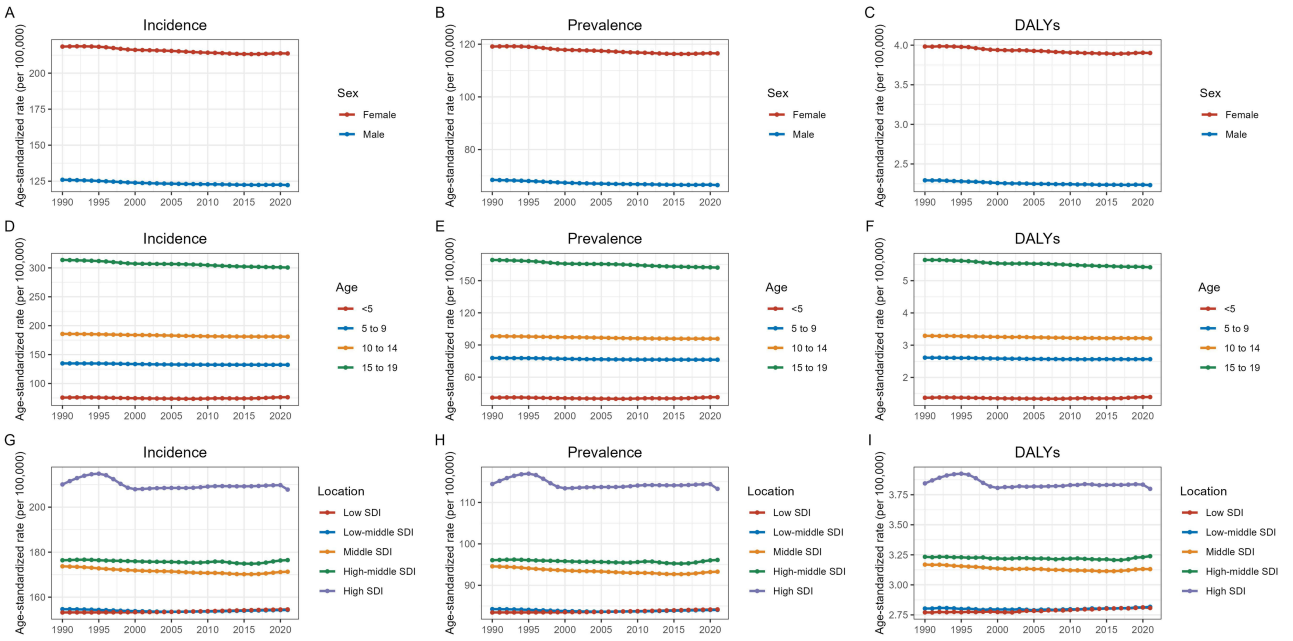

Figure 1 Age-standardized rate of alopecia areata among children and adolescents aged 0–19 years by sex, age, and SDI levels from 1990 to 2021. (**A, D, G**) Age-standardized incidence trends; (**B, E, H**)Age-standardized prevalence trends; (**C, F, I**) Age-standardized DALYs trends.
Abbreviation: DALYs, disability-adjusted life-years.

Age-Subgroup Variations

All four pediatric age subgroups experienced increases in incident cases, prevalent cases, and DALYs from 1990 to 2021. The 10–14 age group showed the highest growth in prevalent cases (21.5%, 525,650 to 638,665), while the <5 age group exhibited the lowest (7.23%, 253,413 to 271,741) (Table 1, Supplementary Table S2 and Figure 1). The 15–19 age group consistently bore the highest proportion of pediatric alopecia areata burden across all metrics (incidence, prevalence, DALYs), with burden proportion decreasing as age decreased (Figure 1). ASIR, ASPR, and ASDR declined across all age subgroups, with the most significant decrease in ASPR observed in the 15–19 age group (EAPC = −0.140) and the slowest in the <5 age group (EAPC = −0.024). Burden metrics escalated with age, peaking in the 15–19 year group and being lowest in the <5 age group (Figure 1 and Supplementary Figures S2–S4).

SDI-Based Disparities

From 1990 to 2021, low and low-middle SDI regions witnessed substantial increases in pediatric alopecia areata incident cases, prevalent cases, and DALYs, particularly in low SDI areas (eg, prevalent cases increased by 122.43%, from 217,490 to 483,756). Conversely, middle, high-middle, and high SDI regions experienced declines, most notably in high-middle SDI prevalent cases (−18.91%, 370,928 to 300,777) (Table 1 and Figure 2). In 2021, middle SDI regions had the highest prevalent cases (722,934), while high SDI regions had the lowest (277,195). Only the low SDI group showed rising trends in ASIR, ASPR, and ASDR (EAPCs = 0.030, 0.030, 0.050, respectively). Other groups declined, with significant reductions in middle (EAPCs = −0.059, −0.059, −0.050) and high SDI regions (EAPCs = −0.059, −0.052, −0.056) (Table 1 and SupplementaryTable S2). Among SDI quintiles in 2021, the high SDI group exhibited the highest ASIR (207.81), ASPR (113.28), and ASDR (3.80) per 100,000. A positive correlation was observed between SDI level and pediatric alopecia areata burden metrics (Table 1, Supplementary Table S2 and Figure 1).

Regional Heterogeneity

South Asia reported the highest burden numerically in 2021 (prevalent cases: 567,916; incident cases: 1,044,502; DALYs: 19,006), while Oceania reported the lowest (prevalent cases: 6,298; incident cases: 11,551; DALYs: 212) (Table 1, Supplementary Table S2 and Supplementary Figures S5–S7). The most rapid growth in prevalent cases

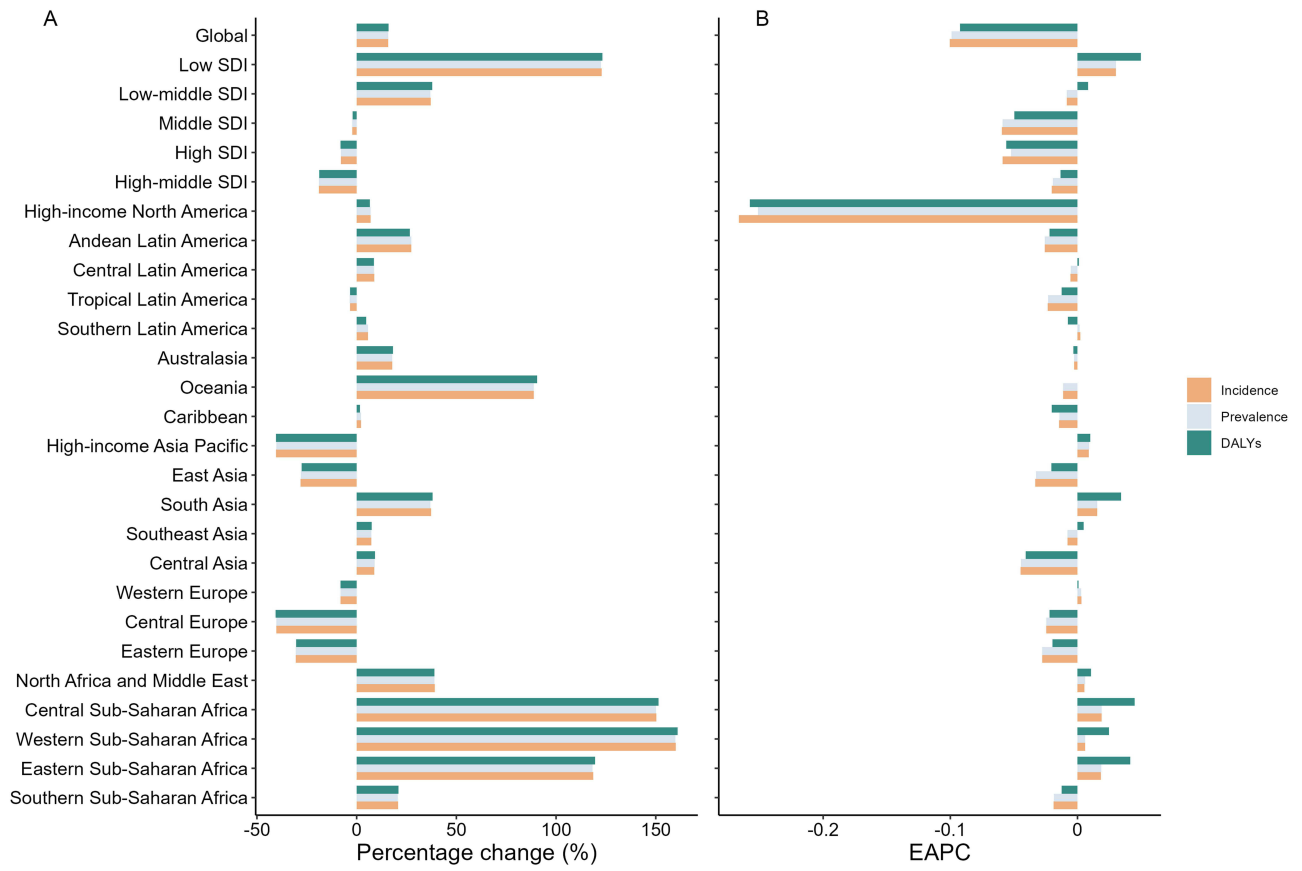

Figure 2 Percentage change and EAPC of alopecia areata in children and adolescents aged 0–19 years. (**A**) Percentage change from 1990 to 2021 at the global, SDI and 21 regions levels; (**B**) EAPC of incidence, prevalence, and DALYs from 1990 to 2021 at the global, SDI, and 21 regions levels.
Abbreviations: DALYs, disability-adjusted life-years; EAPC, estimated annual percentage change; SDI, socio-demographic index.

occurred in Western Sub-Saharan Africa (159.84%), Central Sub-Saharan Africa (150.10%), and Eastern Sub-Saharan Africa (118.35%), all of which increased by more than double. During the same period, the most rapid decrease was observed in High-income Asia Pacific (−40.38%) and Central Europe (−40.32%)(Table 1, Supplementary Table S2, Figures 2 and 3, Supplementary Figures S5–S7). From 1990 to 2021, significant regional variations existed in ASIR, ASPR, and ASDR for alopecia areata among children and adolescents. High-income North America exhibited the highest rates (ASPR: 145.84; ASIR: 128.53; ASDR: 4.30 per 100,000), whereas South Asia had the lowest (ASPR: 79.08; ASIR: 145.18; ASDR: 2.65 per 100,000). Central Sub-Saharan Africa (EAPC=0.019), Eastern Sub-Saharan Africa (EAPC=0.019), and South Asia (EAPC=0.015) showed the largest ASPR increases. The most substantial ASPR declines occurred in High-income North America (EAPC=−0.251) and Central Asia (EAPC=−0.045) (Table 1).

National-Level Variations

Significant heterogeneity in pediatric alopecia areata burden was observed across countries from 1990 to 2021 (Supplementary Tables S3–S5, Figure 4 and Supplementary Figures S8–S11). In 2021, India (420,913), China (332,671), and the United States (111,439) had the highest numbers of prevalent cases, and were also among the world's top three countries by population. Qatar (298.01%), Angola (235.65%), and Chad (216.90%) recorded the largest percentage increases in prevalent cases, while Bosnia and Herzegovina (−54.74%) and Albania (−54.51%) recorded the largest percentage decreases. American Samoa (EAPC=0.061), Bhutan (EAPC=0.059), and Gabon (EAPC=0.05) exhibited the most significant ASPR increases, whereas the United States (EAPC=−0.277), Equatorial Guinea (EAPC=−0.133), and Georgia (EAPC=−0.078) demonstrated the sharpest declines. ASDR decreased notably in many nations, most prominently in the United States (EAPC=−0.284), followed by Georgia (EAPC=−0.086), Armenia (EAPC=

https://doi.org/10.2147/CCID.S582775

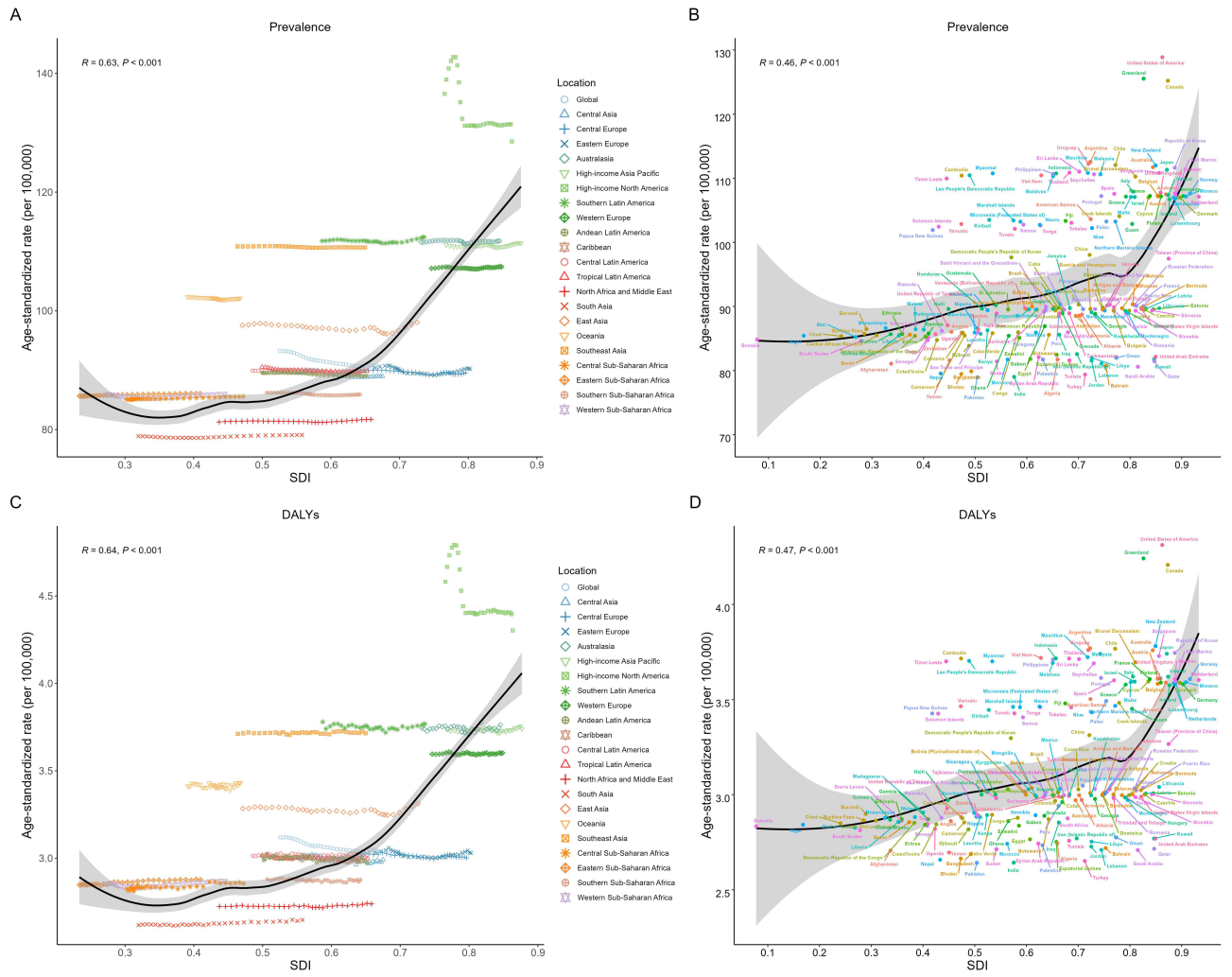

Figure 3 Global, regional, and national levels of alopecia areata in children and adolescents aged 0–19 years by SDI. (**A**) ASPR 1990 to 2021 at the global and 21 regions levels; (**B**) ASPR in 2021 in 204 countries and territories; (**C**) ASDR from 1990 to 2021 at the global and 21 regions levels; (**D**) ASDR in 2021 in 204 countries and territories. For each region, points from left to right depict estimates from each year from 1990 to 2021. Expected trends based on SDI and disease age-standardized rates in all locations were shown as the black line with LOWESS (locally weighted scatterplot smoothing) methods.
Abbreviations: DALYs, disability-adjusted life-years; SDI, socio-demographic index; ASPR, Age-standardized prevalence; ASDR, Age-standardized DALYs.

−0.075), and Equatorial Guinea (EAPC=−0.073). Conversely, Malawi (EAPC=0.075), the United Republic of Tanzania (EAPC=0.071), and American Samoa (EAPC=0.071) had the largest increases in ASDR.

Future Projections of Alopecia Areata Burden

We predicted the incidence, prevalence and DALYs of alopecia areata in children and adolescents aged 0–19 years worldwide from 2022 to 2040. The results showed that the incidence, prevalence and disease burden of alopecia areata in children and adolescents worldwide are stable from 2022 to 2040 and it is expected that there will be no large-scale fluctuations. Since India, China, and United States of America have the highest prevalent cases of alopecia areata in children and adolescents, and are also the three countries with the largest population in the world, we also predict the future trend of India, China and United States of America. The ASPR, ASIR, and ASDR of alopecia areata among children and adolescents continue to rise in China, in contrast to declines in the United States of America and relative stability in India (Figure 5).

Discussion

This investigation provides the first comprehensive assessment of alopecia areata incidence, prevalence, and DALYs specifically among children and adolescents aged 0–19 years across global, regional, and national scales from 1990 to

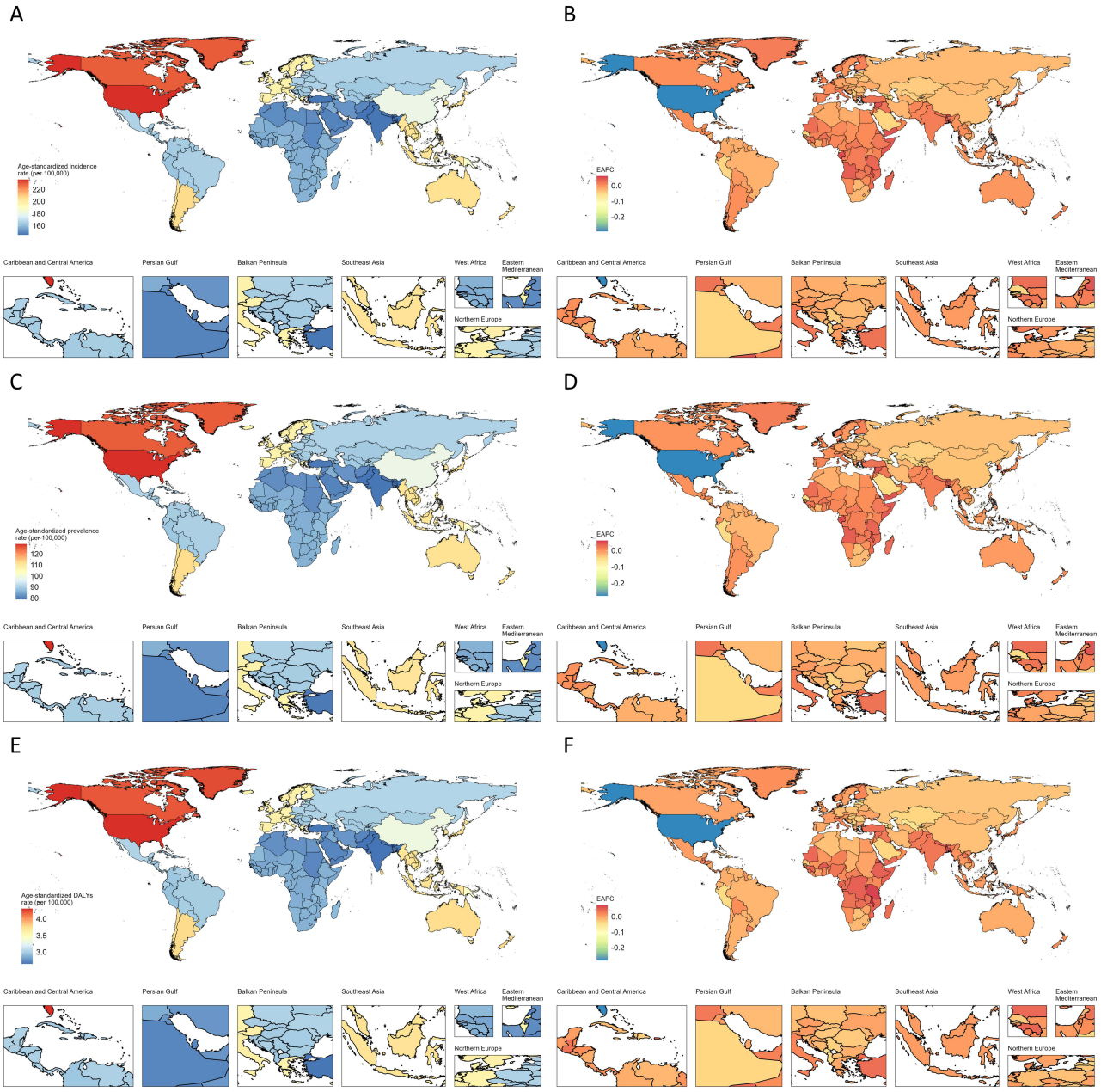

Figure 4 Age-standardized incidence, prevalence, and DALYs of alopecia areata in children and adolescents aged 0–19 years in 204 countries and territories. (**A**) ASIR in 2021; (**B**) EAPC in ASIR from 1990 to 2021; (**C**) ASPR in 2021; (**D**) EAPC in ASPR from 1990 to 2021; (**E**) ASDR in 2021; (**F**) EAPC in ASDR from 1990 to 2021. EAPC estimated annual percentage changes.
Abbreviations: ASIR, Age-standardized incidence; ASPR, Age-standardized prevalence; ASDR, Age-standardized DALYs.

2021. Our research showed that the absolute burden of alopecia areata increased while the relative burden decreased in children and adolescents. Notably, the elevated absolute burden of alopecia areata stems from the "base effect" of global and regional child population expansion, rather than the aggravation of disease severity itself or the regression of prevention and control efforts. In contrast, the decline in ASIR and ASDR reflects the overall improvement in global prevention and control of childhood alopecia areata, driven by evidence-based modifiable factors and early interventions. First, the advancement of global child health screening systems have significantly enhanced the early recognition of childhood alopecia areata, particularly in medium- to high-SDI regions. Early interventions, such as topical corticosteroid therapy and psychological support, can effectively control disease progression, reduce the risk of chronicity, and thereby mitigate the

https://doi.org/10.2147/CCID.S582775

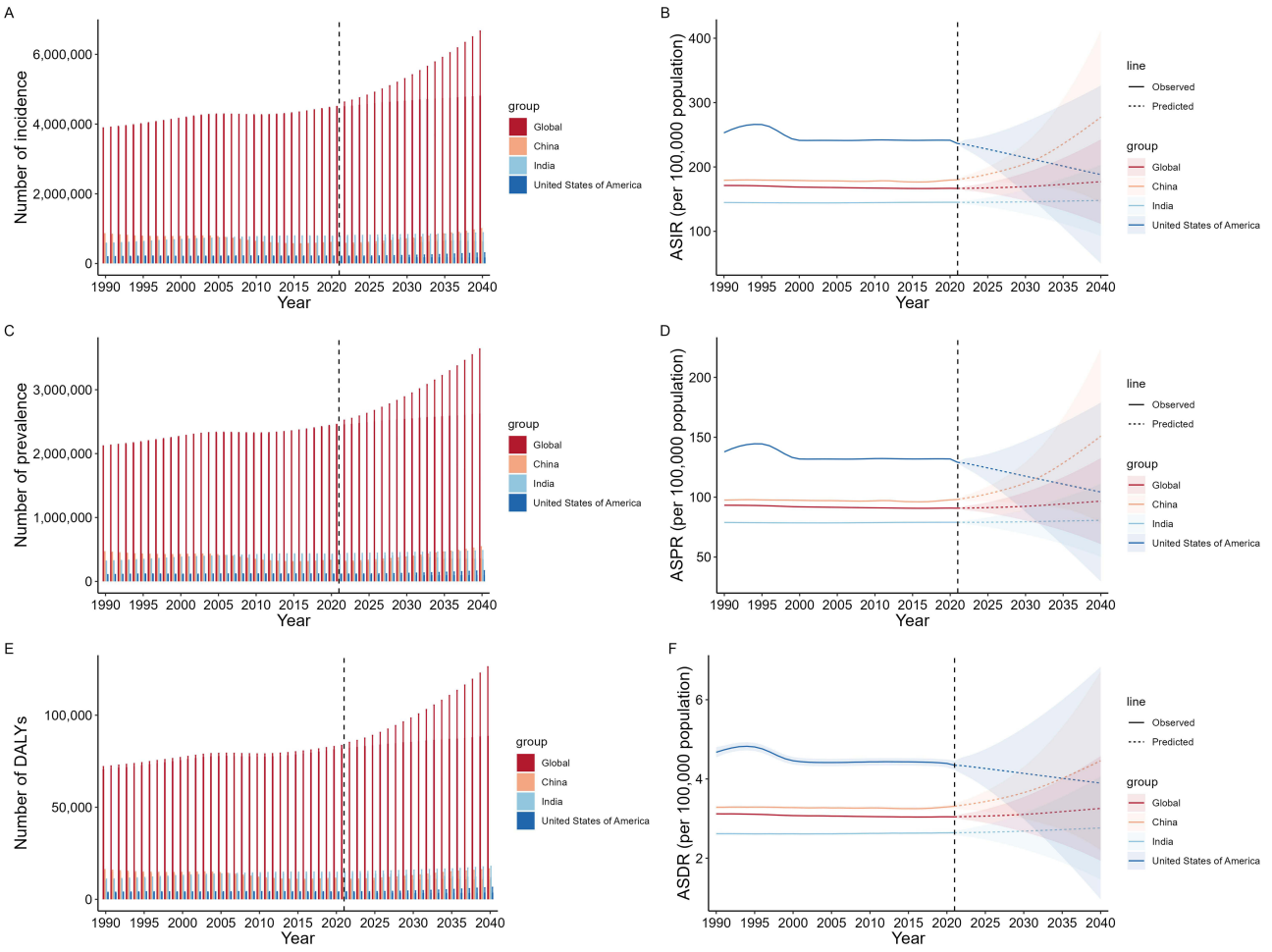

Figure 5 Predicted trends of the burden of alopecia areata in children and adolescents aged 0–19 years from 2022 to 2040 in global, China, India and United States of America. (**A, C, E**) was respectively the number of incidence, prevalence, and DALY of alopecia areata in children and adolescents aged 0–19 years from 2022 to 2040 in global, China, India and United States of America. (**B, D, F**) was respectively ASIR, ASPR, ASPR of alopecia areata in children and adolescents aged 0–19 years from 2022 to 2040 in global, China, India and United States of America. The shaded area in the figure represents the 95% uncertainty interval (UI).
Abbreviations: ASIR, Age-standardized incidence; ASPR, Age-standardized prevalence; ASDR, Age-standardized DALYs.

cumulative impact of morbidity. Second, the occurrence of childhood alopecia areata is closely associated with modifiable factors, including allergic diathesis, comorbid autoimmune diseases (eg, allergic rhinitis, asthma), and psychological stress.[9,11] In recent years, global advances in the prevention and control of childhood allergic disease (eg, allergen exposure management, standardized anti-allergic treatment) and the popularization of child mental health services have effectively reduced the risk of childhood alopecia areata, further contributing to the decline in relative burden indicators.

Multiple epidemiological studies have reported sex differences in the incidence of alopecia areata,[18,19] but data on adolescents aged 0–19 years are particularly scarce. Our research revealed that, in children and adolescents with alopecia areata, females had higher ASIR, ASPR, and ASDR than males did, with percentages of 173%, 175%, and 175%, respectively. Moreover, the downward trend in females was slower than that in males, indicating a persistently greater disease burden in this group. Sex differences between females and males may result from immune-genetic susceptibility, behavior and other factors. Females undergo significant endocrine fluctuations throughout their lives (eg, puberty, pregnancy), and hormones affect immune regulation. Studies have found that estrogens can modulate the Th17/Treg immune balance, which has been implicated in alopecia areata pathogenesis and may be related to disease severity.[18–20] Females also exhibit higher lifetime risks for other autoimmune conditions like rheumatoid arthritis, inflammatory bowel disease, and atopic dermatitis.[10,11,21] Behaviorally, adolescent females often demonstrate greater health awareness regarding conditions affecting appearance, leading to higher healthcare utilization rates and potentially better adherence

 https://doi.org/10.2147/CCID.S582775

to treatment regimens. Future research should delve deeper into the molecular and psychosocial mechanisms underpinning these sex-based differences in alopecia areata in children and adolescents.

One of the main findings in our study was that the 15–19 age group had the highest ASIR, ASPR, and ASDR for alopecia areata among children and adolescents, indicating that adolescence between 15 and 19 years of age was a critical new onset period for alopecia areata and a major disease burden for adolescents. This may be related to the complex relationship between changes in androgen and estrogen levels and autoimmune responses during 15–19 years, followed by increased academic pressure during adolescence.[22,23] Cultural beliefs that associate alopecia areata with "infectious diseases" or "poor hygiene" in underdeveloped areas create stigma among adolescents with alopecia areata, postponed medical treatment and early diagnosis. Although the incidence rate in the <5 years age group exhibited the slowest increase, the decrease in the ASPR was also the slowest, while the value in the 15–19 years age group exhibited the most obvious downward trend. This underscores need to focus disease management efforts not only on the high-burden adolescent group but also on optimizing early childhood detection and intervention. Previous studies identify early AA onset as a predictor of treatment resistance and disease severity.[5] Therefore, early diagnosis and intervention of the disease are crucial for preventing the progression of alopecia areata and minimizing its psychosocial impact on children and adolescents.

Our results also showed large differences across SDI regions. As the SDI increased, the ASIR, ASPR, and ASDR of children and adolescents with alopecia areata also increased. The burden in the high-SDI group was the greatest at that time, but it clearly decreased. On the other hand, the problem of low SDI worsened every day. We need to be careful and pay more attention to this. These findings are consistent with earlier studies, which showed that at the national level, people with higher socioeconomic status had a greater risk of alopecia areata. This might be because they have a worse prognosis with metabolic and autoimmune diseases. The incidence of alopecia areata varies widely geographically among children and adolescents, consistent with existing data. In this study, high-income North America exhibited the highest ASPR, ASIR, and ASDR, suggesting a significant burden of alopecia areata in this region. The disease burden in High-income North America showed the greatest downward trend. In contrast, Central Sub-Saharan Africa demonstrated the most substantial increases in burden rates, signifying an escalating regional challenge. These geographic disparities likely originate from divergent environmental exposures, healthcare access limitations, cultural practices, and socioeconomic condition.[22–25] Studies indicate higher lifetime AA incidence and associated anxiety, particularly impacting work absenteeism, among Black populations predominantly residing in Central Sub-Saharan Africa. Factors prevalent in this region, including dense populations, suboptimal living conditions that increase inflammation risk, micronutrient deficiencies (eg, vitamin D, zinc, folate) linked to alopecia areata and limited healthcare resources, contribute to this rising burden.[26–28] The health-care setting in central sub-saharan Africa (low SDI region) is characterized by: (1) an extreme shortage of dermatologists and pediatric dermatologists, with a physician-to-population ratio well below the global average; (2) limited access to diagnostic tools (such as dermoscopy) and treatment options (such as first-line topical immunotherapy); and (3) severely inadequate public health system attention and resource allocation for nonfatal, noncommunicable skin diseases. Although alopecia areata is not directly life-threatening, its high morbidity, ongoing burden, and potentially serious psychosocial consequences, coupled with the "Minor illness-major impairment" effect exacerbated by extreme medical resource constraints, have been a major concern for the health-care industry, it is of great public health urgency and health equity significance to develop and implement cost-effective alopecia areata, screen and standardize the diagnosis and management of alopecia areata.[29–32] We recommend that international organizations, aid agencies, and national health authorities work together to prioritize community-based and primary health care-based skin health training programs in these regions, while exploring innovative solutions such as distal dermatology.

We used the BAPC model to predict the burden of alopecia areata in children and adolescents aged 0–19 years worldwide from 2022 to 2040, revealing a significant contrast: in China, the burden of alopecia areata among children will continue to increase, while in the United States it will continue to decline. This difference stems from specific drivers in different countries.

In China, fierce academic competition exposes children to long after-school tutoring and heavy homework, leading to long-term elevated psychological stress, which may activate the hypothalamic-pituitary-adrenal (HPA) axis, intensify autoimmune responses and increase the risk of alopecia areata. Second, rapid urbanization and industrialization have led to ongoing environmental challenges, including air pollution that disrupts immune regulation, and dietary westernization that affects gut microbiota balance and systemic inflammation (eg, increased intake of high sugar and processed foods),

both of which contribute to an increased risk of alopecia areata.[33,34] Third, increased awareness of diagnosis has enabled more mild-to-moderate cases to be identified, resulting in higher reported prevalence rates. These intertwined factors have exacerbated the rising burden of alopecia areata among children in China, calling for the development of comprehensive prevention and control strategies that combine mental health support, environmental intervention and public education.

In contrast, the continued decline in the burden of alopecia areata in the United States is attributed to an optimized and mature prevention and control system. First, despite high academic pressure, the United States has a mature and widely available mental health support system for children and adolescents, which effectively alleviates the psychosocial impact of stress on the development of alopecia areata. Second, the US health care system is characterized by a mature hierarchical diagnosis and treatment model and extensive health insurance coverage, ensuring timely access to early screening and standardized interventions in children with alopecia areata.[3,24] This early intervention reduces the chronic risk of disease and the cumulative burden of disease.

Treatment options for children with alopecia areata remain limited compared to those available for adults.[35–37] Systemic oral corticosteroids are a commonly used systemic treatment for childhood alopecia areata, typically providing a good initial response, but with a high recurrence rate after discontinuation and a high risk of long-term side effects. Evidence supporting the use of traditional immunomodulators (methotrexate, cyclosporine, azathioprine) in children is limited. The recent in-depth understanding of the pathogenesis of alopecia areata has promoted the development of new treatment strategies, such as Janus kinase (JAK) inhibitors, biologics, and several small molecule drugs. However, JAK is currently only suitable for children over 12 years old and is expensive. Innovative strategies to address the complex interplay among genetic, hormonal, environmental, and lifestyle factors in alopecia areata are essential. Tailoring personalized regimens to individual patient profiles can optimize treatment outcomes while reducing adverse effects. Further, incorporating nutritional optimization and stress reduction into care protocols may augment clinical interventions and alleviate disease burden.

Strengths and Limitations

Using the GBD dataset, this study provides a more refined age decomposition, regional differences, and projections of future global, Indian, China, and US burden of childhood alopecia areata. However, limitations still need attention. The quality and availability of data on the burden of childhood alopecia vary by location and time, potentially affecting the accuracy of estimates. For example, GBD in low-income countries may lack high-quality registration data for children with alopecia areata, relying on models combined with limited data extrapolation to produce estimates, and there are uncertainties. Second, the analysis primarily describes trends in burden, without establishing the causal mechanisms underlying the observed patterns Future research should prioritize identifying specific risk factors and elucidating the mechanisms underlying differential burden of alopecia areata across age, sex, geography, and socioeconomics.

Conclusion

In conclusion, compared to 1990, the global incident cases, prevalent cases, and DALYs of alopecia areata among children and adolescents had increased in 2021, but overall the ASIR, ASPR, and ASDR were on a downward trend. Specific demographic groups—females, adolescents aged 15–19 years, and populations in low-SDI regions, particularly within Central Sub-Saharan Africa—continue to face disproportionately high burdens, demanding targeted interventions and resource allocation. Despite the encouraging downward trajectory in relative burden, AA remains a significant health threat for youth globally. The disease burden of alopecia areata among children and adolescents worldwide and in India will tend to be stable from 2022 to 2040. In China, the disease burden will continue to rise, while in the United States it will continue to decline. Sustained implementation of effective public health measures is crucial to further mitigate its impact. The epidemiological evidence presented here serves as a vital foundation for guiding future research priorities, shaping prevention programs, and informing equitable resource distribution strategies for pediatric alopecia areata.

Abbreviations

ASIR, Age-standardized incidence rate; ASPR, age-standardized prevalence rate; ASDR, Age-standardized DALYs rate; DALYs, Disability-adjusted life years; EAPC, Estimated annual percentage change; GBD, Global Burden of Disease; SDI, Socio-demographic index; UI, Uncertainty interval.

Data Sharing Statement

Data resources from the GBD study 2021 could be accessed online through the Global Health Data Exchange (GHDx) query tool (http://ghdx.healthdata.org/gbd-results-tool).

Ethics Statements

According to Article 32 of the Ethical Review Measures for Life Science and Medical Research Involving Human Beings of the People's Republic of China, the data used in this study will not cause any form of harm to human beings, nor will it touch sensitive personal privacy or trade secrets, so the ethical review can be exempted. In addition, the database used in this study was publicly available and legally available.

Acknowledgments

We highly appreciated the works by the Global Burden of Disease Study 2021 collaborators.

Author Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

Funding

This work was supported by National Key R&D Program of China (2023YFC2508200); Beijing Hospitals Authority's Ascent Plan (DFL20241201); BoRun Dermatology Postgraduate (Supervisor) Fund (KH002475).

Disclosure

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

References

1. Lee HH, Gwillim E, Patel KR, et al. Epidemiology of alopecia areata, ophiasis, totalis, and universalis: a systematic review and meta-analysis. *J Am Acad Dermatol*. 2020;82(3):675–682. doi:10.1016/j.jaad.2019.08.032
2. Wang H, Pan L, Wu Y. Epidemiological trends in alopecia areata at the global, regional, and national levels. *Front Immunol*. 2022;13. doi:10.3389/fimmu.2022.874677
3. Mostaghimi A, Gao W, Ray M, et al. Trends in prevalence and incidence of alopecia areata, alopecia totalis, and alopecia universalis among adults and children in a US employer-sponsored insured population. *JAMA Dermatol*. 2023;159(4):411. doi:10.1001/jamadermatol.2023.0002
4. Jeon JJ, Jung S, Kim YH, et al. Global, regional and national epidemiology of alopecia areata: a systematic review and modelling study. *Brit J Dermatol*. 2024;191(3):325–335. doi:10.1093/bjd/ljae058
5. Starace M, Alessandrini AM, Cua VCS, et al. Retrospective study correlating the clinical outcome of alopecia areata with specific prognostic factors. *J Eur Acad Dermatol*. 2022;37(4). doi:10.1111/jdv.18748
6. Bilgi BA, Bahal K, Bahali AG, Gürkan A, Lmaz SY, Yılmaz S. Psychiatric symptomatology and health-related quality of life in children and adolescents with alopecia areata. *J Eur Acad Dermatol*. 2013;28(11):1463–1468. doi:10.1111/jdv.12315
7. SSE A, Gür TBF, An BD. Anxiety and depression in pediatric patients with vitiligo and alopecia areata and their parents: a cross-sectional controlled study. *J Cosmet Dermatol*. 2020;20(7):2232–2239. doi:10.1111/jocd.13807
8. Altunisik N, Ucuz I, Turkmen D. Psychiatric basics of alopecia areata in pediatric patients: evaluation of emotion dysregulation, somatization, depression, and anxiety levels. *J Cosmet Dermatol*. 2021;21(2):770–775. doi:10.1111/jocd.14122
9. Ly S, Manjaly P, Kamal K, et al. Comorbid conditions associated with alopecia areata: a systematic review and meta-analysis. *Am J Clin Dermatol*. 2023;24(6):875–893. doi:10.1007/s40257-023-00805-4
10. Conic RZ, Tamashunas NL, Damiani G, Fabbrocini G, Cantelli M, Bergfeld WF. Comorbidities in pediatric alopecia areata. *J Eur Acad Dermatol*. 2020;34(12):2898–2901. doi:10.1111/jdv.16727
11. Adhanom R, Ansbro B, Soccio LC. Epidemiology of pediatric alopecia areata. *Pediatr Dermatol*. 2025;42(S1):12–23. doi:10.1111/pde.15803
12. Jang H, Park S, Kim MS, et al. Global, regional and national burden of alopecia areata and its associated diseases, 1990–2019: a systematic analysis of the global burden of disease study 2019. *Eur J Clin Invest*. 2023;53(6). doi:10.1111/eci.13958
13. Zhou J, Liang L, Zhang H, et al. Global burden of alopecia areata and associated diseases: a trend analysis from 1990 to 2021. *J Cosmet Dermatol*. 2025;24(3):e70076. doi:10.1111/jocd.70076
14. Li X, Liu H, Ren W, et al. Burden of alopecia areata in China, 1990–2021: global burden of disease study 2021. *Chin Med J*. 2024. doi:10.1097/cm9.0000000000003373

15. GBD 2021 Diseases and Injuries Collaborators. Global incidence, prevalence, years lived with disability (YLDs), disability-adjusted life-years (DALYs), and healthy life expectancy (HALE) for 371 diseases and injuries in 204 countries and territories and 811 subnational locations, 1990-2021: a systematic analysis for the global burden of disease study 2021. *Lancet*. 2024;403(10440):2133–2161. doi:10.1016/S0140-6736(24)00757-8
16. Vos T, Lim SS, Abbafati C, et al. Global burden of 369 diseases and injuries in 204 countries and territories, 1990–2019: a systematic analysis for the global burden of disease study 2019. *Lancet*. 2020;396(10258):1204–1222. doi:10.1016/s0140-6736(20)30925-9
17. Brauer M, Roth GA, Aravkin AY, et al. Global burden and strength of evidence for 88 risk factors in 204 countries and 811 subnational locations, 1990–2021: a systematic analysis for the global burden of disease study 2021. *Lancet*. 2024;403(10440):2162–2203. doi:10.1016/s0140-6736(24)00933-4
18. Dou DR, Zhao Y, Belk JA, et al. Xist ribonucleoproteins promote female sex-biased autoimmunity. *Cell*. 2024;187(3):733–749.e16. doi:10.1016/j.cell.2023.12.037
19. Natri H, Garcia AR, Buetow KH, Trumble BC, Wilson MA. The pregnancy pickle: evolved immune compensation due to pregnancy underlies sex differences in human diseases. *Trends Genet*. 2019;35(7):478–488. doi:10.1016/j.tig.2019.04.008
20. Bernardini N, Skroza N, Tolino E, et al. IL-17 and its role in inflammatory, autoimmune, and oncological skin diseases: state of art. *Int J Dermatol*. 2019;59(4):406–411. doi:10.1111/ijd.14695
21. Lee S, Lee H, CH L, Lee W. Comorbidities in alopecia areata: a systematic review and meta-analysis. *J Am Acad Dermatol*. 2019;80(2):466–477.e16. doi:10.1016/j.jaad.2018.07.013
22. Hammadi AA, Parmar NV, Aljefri K, et al. Review on alopecia areata in the Middle East And Africa: landscape and unmet needs. *Dermatology Ther*. 2023;13(7):1435–1464. doi:10.1007/s13555-023-00946-8
23. Thompson JM, Mirza MA, Park MK, Qureshi AA, Cho E. The role of micronutrients in alopecia areata: a review. *Am J Clin Dermatol*. 2017;18(5):663–679. doi:10.1007/s40257-017-0285-x
24. Thompson AR, Tziotzios C, Nesnas J, Randall R, Czachorowski M, Messenger A. Lifetime incidence and healthcare disparities in alopecia areata: a UK population-based cohort study. *Br J Dermatol*. 2024;191(6):924–935. doi:10.1093/bjd/ljae307
25. Rudnicka L, Arenbergerova M, Grimalt R, et al. European expert consensus statement on the systemic treatment of alopecia areata. *J Eur Acad Dermatol*. 2024;38(4):687–694. doi:10.1111/jdv.19768
26. Tsai T, Huang Y. Vitamin D deficiency in patients with alopecia areata: a systematic review and meta-analysis. *J Am Acad Dermatol*. 2018;78(1):207–209. doi:10.1016/j.jaad.2017.07.051
27. Kechichian E, Ezzedine K. Vitamin D and the Skin: an Update for Dermatologists. *Am J Clin Dermatol*. 2017;19(2):223–235. doi:10.1007/s40257-017-0323-8
28. Jiménez-Herrera EA, López-Zenteno BE, Corona-Rodarte E, et al. Vitamin D and alopecia areata: from mechanism to therapeutic implications. *Skin Appendage Disor*. 2025:1–17. doi:10.1159/000545711
29. Florio P, Freire S, Melchiorri M. Estimating geographic access to healthcare facilities in Sub-Saharan Africa by degree of urbanisation. *Appl Geogr*. 2023;160:None. doi:10.1016/j.apgeog.2023.103118
30. Bao J, Yang J, Guo B, Mo J, She Q, Li A. Trends in all-cause mortality attributable to particulate matter 2.5 pollution in Sub-Saharan Africa: an age-period-cohort analysis. *Ecotox Environ Safe*. 2025;303:118979. doi:10.1016/j.ecoenv.2025.118979
31. Djomekui BLS, Ngouanet C, Smit W. Urbanization and health inequity in sub-saharan africa: examining public health and environmental crises in Douala, Cameroon. *Int J Environ Res Public Health*. 2025;22(8):1172. doi:10.3390/ijerph22081172
32. Liu J, Ye Z, Cai Y, et al. Unmasking the rising global burden of depression: a 32-year GBD analysis of gender disparities and regional hotspots in Sub-Saharan Africa. *PLoS One*. 2025;20(7):e0326974. doi:10.1371/journal.pone.0326974
33. Zhang M, Wang Y, Hu S, Wu Y. Causal relationships between air pollution and common autoimmune diseases: a two-sample mendelian randomization study. *Sci Rep*. 2025;15(1):135. doi:10.1038/s41598-024-83880-9
34. Zhao C, Xu Z, Wu G, et al. Emerging role of air pollution in autoimmune diseases. *Autoimmun Rev*. 2019;18(6):607–614. doi:10.1016/j.autrev.2018.12.010
35. Kalil L, Welch D, Heath CR, Craiglow BG. Systemic therapies for pediatric alopecia areata. *Pediatr Dermatol*. 2025;42(S1):36–42. doi:10.1111/pde.15822
36. Zhou C, Li X, Wang C, Zhang J. Alopecia areata: an update on etiopathogenesis, diagnosis, and management. *Clin Rev Allergy Immunol*. 2021;61(3):403–423. doi:10.1007/s12016-021-08883-0
37. Dainichi T, Iwata M, Kaku Y. Alopecia areata: what's new in the epidemiology, comorbidities, and pathogenesis? *J Dermatol Sci*. 2023;112(3):120–127. doi:10.1016/j.jdermsci.2023.09.008