

# Economic Burden of Atopic Dermatitis in Taiwan

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**Atopic dermatitis is a prevalent inflammatory skin disease that manifests clinically as pruritus and eczema. Severe forms of atopic dermatitis can be chronic and relapsing or associated with other dermatological complications and comorbidities, resulting in lifelong impacts across multiple aspects for patients. This study was conducted to calculate the atopic dermatitis-related economic burden in Taiwan. First, the out-of-pocket costs incurred by 200 patients with atopic dermatitis were estimated using a specifically designed questionnaire. Secondly, work impairment was converted into quantifiable costs. The costs reimbursed by the Taiwan National Health Insurance (NHI), which were estimated in our previous work, were included in the final calculation. The atopic dermatitis-related economic burden for patients in Taiwan in 2018 was estimated as (2018 New Taiwan dollars; NT\$) 37.90 billion, which is 0.207% of Taiwan's gross domestic product. This substantial economic burden suggests an existing need for more effective and equitable treatment for atopic dermatitis.**

*Key words:* atopic dermatitis; cost of illness; burden of disease.

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Atopic dermatitis (AD) is a prevalent inflammatory skin disease with reported prevalence rates ranging from 15% to 25% in children and from 1% to 10% in adults (1). Classical AD manifestations are pruritic eczematous skin lesions, often accompanied by other clinical findings (2). In severe cases, patients may experience chronic and relapsing eczema, intense pruritus, dermatological complications, and additional comorbidities, such as autoimmune disorders, atopic disorders, ocular disorders, chronic urticaria, ischaemic heart disorders, and cerebrovascular disorders (3, 4). Consequently, AD has adverse impacts on multiple aspects, including quality of life, social aspects, academic aspects, work productivity, and financial impacts (5–7). Therefore, due to the increasing prevalence rate and lifelong impacts associated with AD, the societal costs of AD have become an important issue (8, 9).

## SIGNIFICANCE

Atopic dermatitis is common skin disease that can result in discomfort and inconvenience to patients and their family members from a range of different aspects, including physically, mentally, and financially. This study aims to calculate the total atopic dermatitis-related economic burden by adding up the estimated out-of-pocket costs, costs of work productivity loss from a meticulously designed questionnaire from 200 patients in Taiwan, and costs reimbursed by the Taiwan National Health Insurance estimated in our previous work. The results show that the out-of-pocket costs and costs of work productivity are major contributors to the total burdens and should not be overlooked.

To fully assess the economic burdens associated with AD, considerations should include direct costs paid by the government and individuals and the costs of lost work productivity due to physical and mental anguish. Although the economic burden associated with AD has been examined in both Western and Eastern countries, only a few studies have included all related costs (10–12). Most studies calculating AD-related costs consider only some economic aspects. Several studies have emphasized the costs of reimbursements from either public or private health insurance programmes (13–16). A few studies have focused on out-of-pocket (OOP) payments paid by patients (17–19), and some studies have focused on the costs associated with lost work productivity (5, 20). Comprehensive estimates of the AD-related economic burden are relatively rare, especially for Asian countries, requiring further investigation.

Two separate studies have examined the health-care costs associated with AD-related comorbidities in Taiwan, both of which utilized the National Health Insurance Research Database (NHIRD) (4, 16). In addition, Chan et al. (7) investigated AD-related work productivity and activity impairment using a questionnaire. However, estimates of AD-related OOP costs and the costs associated with work productivity impairment due to absenteeism or presenteeism have not yet been examined.

The aim of this study was to estimate the OOP costs paid by patients with AD and their family members based on a specifically designed questionnaire (Appendix S1). To obtain a more comprehensive view of the overall economic burden associated with AD, we also quantified the costs of work productivity impairment. In addition to individual expenses and loss, AD is associated with

societal costs in the form of National Health Insurance (NHI) reimbursements, which were estimated in our previous work (16). These costs should also be taken into account when considering the total AD-related economic burden. The resulting comprehensive estimation of AD-related economic burden should both inform patients with AD of the potential economic burden associated with the disease and encourage the optimization of AD treatments.

## MATERIALS AND METHODS

### *Study design and patient recruitment*

From October 2018 to April 2019, a total of 200 patients aged 20 years or older who were diagnosed with AD by a board-certified dermatologist were interviewed in person by well-trained interviewers during regular follow-up visits to the outpatient clinics at 3 participating hospitals located in northern, central, and southern Taiwan. A stratified sampling design was adopted to ensure sufficient recruitment of participants in each of the 3 disease severity groups. Disease severity was assessed by dermatologists using Scoring Atopic Dermatitis (SCORAD). Among patients who completed the interview, the final numbers of patients with mild, moderate, and severe AD were 70, 72, and 58, respectively. A more detailed description has been reported elsewhere (7).

### *Estimation of out-of-pocket costs incurred by atopic dermatitis*

Detailed information regarding AD-associated OOP costs paid by the patient or their family but not reimbursed by the NHI was collected using questionnaires. OOP costs were then categorized into 3 types: general OOP costs, transportation-related OOP costs, and OOP costs for complementary medical materials (1). General OOP costs include the costs of registration fees, co-payments, or other expenses not covered by the NHI incurred when seeking outpatient and inpatient care for the treatment of AD. General OOP costs per visit were estimated by asking patients to report the OOP costs associated with the most recent outpatient visit during the last 3 months. General OOP costs per hospitalization were estimated by asking patients to report the OOP costs associated with the most recent hospitalizations due to AD during the last year (2). Patients were asked to report the OOP costs associated with transportation to attend the most recent outpatient visit for AD treatment within the past 3 months. OOP transportation costs per visit were estimated by asking patients to report the 1-way transportation fares associated with follow-up visits. Patients who travelled by private car or motorcycle were asked to report the time spent driving, and transportation costs were approximated by estimating the cost of fuel for each visit. Assuming a driving speed of 60 km/h, the time spent driving was equal to the distance travelled to reach the clinic (in km). Motorcycles were assumed to be able to travel 40 km per litre of fuel, and cars were assumed to be able to travel 10 km per litre of fuel. The cost of travel was estimated by determining the amount of fuel needed to make a one-way trip to the clinic and multiplying this amount by the cost of fuel (2018 New Taiwan dollars (NT \$30.58 = US\$1); NT\$29.28 per litre) (3). Patients were asked to report OOP expenses associated with complementary medications, such as herbal medicines, folk medicines, dietary supplements, and health foods, as well as medical materials associated with AD, during the previous year.

Annual general OOP costs associated with medical treatments for AD were estimated for each AD severity level by multiplying the mean general OOP costs per visit and per hospitalization by the respective number of previously reported annual AD-associated

outpatient visits and hospitalizations (16). Similarly, annual transportation costs were estimated for each AD severity level by first doubling the mean transportation cost per visit (to reflect travel to and from the clinic) and multiplying the result by the number of previously reported annual AD-associated outpatient visits (16).

### *Estimation of productivity loss due to AD*

Annual productivity losses due to AD were estimated as follows. First, annual incomes were estimated for each AD severity level based on the 2018 mean annual incomes reported for each age group in the working population (15–24 years, NT\$318,408; 25–44 years, NT\$457,104; 45–64 years, NT\$510,528; and 65 years or older, NT\$406,812) (21). Incomes were then weighted by the percentages of patients with AD in each age group, according to the NHIRD, as described in a previous study (16). The resulting estimated annual incomes used for this study were NT\$434,892 for mild AD, NT\$433,169 for moderate AD, and NT\$438,007 for severe. Secondly, the estimated productivity loss due to work impairment associated with both absenteeism and presenteeism was estimated by multiplying the mean annual income by the corresponding mean Work Productivity and Activity Impairment (WPAI) scores for each severity level (mild AD: 24.7%; moderate AD: 44.8%; and severe AD: 65.0%) reported previously by Chan et al. (7).

### *Estimation of the economic burdens associated with atopic dermatitis*

The total economic burden associated with AD was estimated by adding total direct medical costs financed by NHI, as reported previously (16); total OOP costs; and the estimated costs of productivity loss.

### *Statistical analysis*

Descriptive statistics for study participants who completed patient interviews were reported previously by Chan et al. (7). Crude values for each OOP category are presented according to disease severity, based on the unadjusted proportions of costs incurred and unadjusted OOP costs for those with positive values. To account for the zeroness and right-skewing nature of the distribution of costs, OOP costs were analysed using a 2-part model consisting of logistic regression to predict the probability of costs incurred and a generalized linear model to predict costs among those with positive values. Covariates were entered into the models to predict OOP costs, including sex, age, body mass index, education, marital status, and household income. Differences in mean adjusted values for each OOP cost category among severity levels were assessed by analysis of variance. All costs were reported in 2018 New Taiwan dollars (NT \$30.58 = US\$1).

Findings with a 2-sided  $p$ -value of  $\leq 0.05$  were considered significantly different between groups. All analyses were performed using SAS/Stat system for Windows, version 9.4 (SAS Institute, Cary, NC, USA).

## RESULTS

### *Out-of-pocket costs*

**Table I** lists OOP payments according to disease severity, including transportation costs, outpatient costs, inpatient costs, and other costs. OOP outpatient costs per visit were NT\$419.5 for patients with mild AD, NT\$411.2 for patients with moderate AD, and NT\$437 for patients with severe AD, with no significant differences ( $p=0.27$ ).

**Table I. Crude values and regression-adjusted values for out-of-pocket (OOP) costs per patient per year (in 2018 New Taiwan dollars; NT\$)**

	Crude values				Regression-adjusted values	
	Proportion of non-zero costs		Among those with non-zero costs		Mean ± SD	p-value
	N	n (%)	Mean ± SD	Median [IQR]		
OOP costs incurred for outpatient visits						0.27
Mild	70	54 (77.1)	555.1 ± 217	520 [80]	419.5 ± 87.6	
Moderate	72	64 (88.9)	539.3 ± 230	520 [130]	411.2 ± 90.7	
Severe	58	50 (86.2)	544.4 ± 255.6	520 [80]	437 ± 94.2	
All	200	168 (84)	545.9 ± 232.6	520 [100]	421.6 ± 90.8	
OOP costs incurred for hospitalization <sup>a</sup>						-
Mild	70	0 (0)	-	-	-	-
Moderate	72	1 (1.4)	3,500.00	-	-	-
Severe	58	2 (3.4)	10,550.00 ± 13,364.30	-	-	-
All	200	3 (1.5)	8,200.00 ± 10,289.30	3,500.00 [18,900.00]	-	-
Transportation costs						0.02
Mild	140	106 (151.4)	121.2 ± 220.4	48 [64.8]	89.8 ± 54.4	
Moderate	144	110 (152.8)	135.6 ± 185.2	60 [132]	111.2 ± 65.6	
Severe	116	94 (162)	181.8 ± 401	60 [136]	133.4 ± 124.8	
All	400	310 (155)	144.6 ± 277.6	60 [136]	110.2 ± 85.6	
Other OOP costs <sup>b</sup>						< 0.0001
Mild	70	51 (72.9)	7,051.00 ± 8,568.50	3,000.00 [8,000.00]	5,248.20 ± 3,955.50	
Moderate	72	58 (80.6)	11,681.00 ± 18,386.40	5,000.00 [10,600.00]	8,794.10 ± 5,710.20	
Severe	58	49 (84.5)	20,944.90 ± 38,079.50	8,000.00 [16,300.00]	18,015.70 ± 19,387.80	
All	200	158 (79)	13,059.50 ± 24,925.50	5,750.00 [10,000.00]	10,227.30 ± 12,323.50	

<sup>a</sup>Regression-adjusted values were not computed due to the small number of patients who received inpatient care. <sup>b</sup>Including complementary medication, such as herbal medicine, folk medicine, dietary supplements, and health food, as well as medical materials associated with atopic dermatitis.

IQR: interquartile range; SD: standard deviation.

Other costs were NT\$5,248.2, NT\$8,794.1, and NT\$18,015.7 in patients with mild, moderate, and severe AD, respectively, reaching statistical significance ( $p < 0.0001$ ). The regression-adjusted values for inpatient costs could not be computed due to the small number of patients who received inpatient care; therefore, costs involving inpatient care were not included in the calculation of the economic burden of AD.

### Costs of productivity loss

**Table II** shows the final costs associated with work productivity loss according to AD severity, which were NT\$107,418, NT\$194,060, and NT\$284,705 for patients with mild, moderate, and severe AD, respectively.

### Total atopic dermatitis-associated economic burden

**Fig. 1** displays the annual costs per patient with mild, moderate, and severe AD are NT\$126,938, NT\$218,453, and NT\$327,741, respectively. The most significant

economic burdens experienced by patients with AD were associated with the costs of work productivity loss across all 3 AD severity levels, contributing 84.62%, 88.83%, and 86.87% of the total expenses associated with mild, moderate, and severe AD, respectively. Costs reimbursed by the NHI were the smallest components of the total cost, representing only 7.49%, 4.44%, and 4.81% of the costs associated with mild, moderate, and severe AD, respectively. For details of itemized costs, please refer to Table S1.

## DISCUSSION

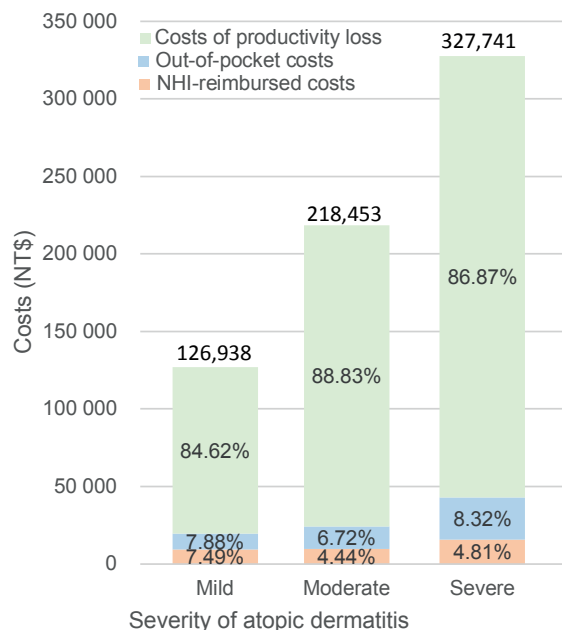
### Out-of-pocket costs and associations with disease severity

Using a questionnaire designed specifically for this study, the OOP costs were calculated as representing 10–15% of the total costs associated with AD, with estimated means of NT\$10,008, NT\$14,688, and NT\$27,274 reported by patients with mild, moderate, and severe AD, respectively (equivalent to US\$327.3, US\$480.3, and US\$891.9, respectively, using a conversion rate of NT\$30.58 = US\$1). Chinese medicines, moisturizers, and dietary supplements were the major contributors to OOP costs. In a cross-sectional study conducted in 9 European countries and analysing 1,189 patients receiving systemic treatments or phototherapy, the mean annual OOP expenses per patient were reported to be US\$1047.65 (€927.12, using a conversion rate of €1 = US\$1.13),

**Table II. Estimated costs of productivity loss per patient (in 2018 New Taiwan dollars; NT\$), based on the annual income of employed persons and Work Productivity and Activity Impairment Questionnaire (WPAI) scores**

Age group	Mean annual income of employed persons (NT\$) (21)	Percentage of patients with AD (NHIRD)			
		Mild	Moderate	Severe	Total
15–24 years	318,408	17.37%	19.85%	15.14%	17.78%
25–44 years	457,104	32.51%	33.64%	28.92%	32.40%
45–64 years	510,528	27.41%	26.02%	28.92%	27.41%
≥65 years	406,812	22.38%	20.49%	27.03%	22.41%
		100.00%	100.00%	100.00%	100.00%
Mean annual income of patients with AD (NT\$)		434,892	433,169	438,007	435,817
Work impairment (%) (7)		24.7	44.8	65.0	43.8
Costs of productivity loss (NT\$)		107,418	194,060	284,705	190,888

AD: atopic dermatitis; NHIRD: National Health Insurance Research Database.



**Fig. 1. Annual economic burden of atopic dermatitis per patient in Taiwan by disease severity.** NHI: National Health Insurance; NT\$: 2018 New Taiwan dollars.

which was much higher than any of the AD groups in our study (17). The patients in the European study tended to have higher education levels, which may indicate an improved ability to pay for extra costs, and the overall disease severity was high among these patients due to the applied inclusion criteria for this study. Fivenson et al. (11) estimated mean annual OOP costs of US\$147, with greater than 75% of total OOP expenses associated with household items and medications. The much lower cost reported by Fivenson et al. (11) relative to the current study may be due to differences in the study years (2002 vs 2018), which may have contributed to differences in the disease prevalence and the exchange rates. In addition, complementary and alternative medicines are less popular in the USA than in Taiwan.

#### *Cost of work productivity loss*

In the current study, the costs associated with work productivity loss were US\$3512.7, US\$6346.0, and US\$9310.2 for patients with mild, moderate, and severe AD, respectively, constituting 84.62%, 88.83% and 86.87% of total expenses. Fivenson et al. (11) calculated productivity loss by multiplying work days lost due to AD by residence-adjusted gross annual income, reporting annual costs per patient of US\$181.51, US\$280.82 and US\$2,159.65 for mild, moderate, and severe AD, respectively. These results indicate that costs increase with disease severity. However, the much lower results reported by Fivenson et al. (11) compared with the costs calculated for the current study might be due to the lack of consideration for presenteeism in that study. A study from the USA in 2017 also utilized the WPAI score to

calculate the costs of productivity loss, considering both work absenteeism and presenteeism, resulting in an estimated annual cost of US\$8907 per patient associated with work productivity loss, which is similar to our results (5).

#### *Total costs of atopic dermatitis-associated economic burden in Taiwan*

This study attempted to provide a thorough evaluation of the AD-associated costs in Taiwan by integrating healthcare-reimbursed costs, which were calculated in a previous study. The results showed that the annual economic burden combining NHI-reimbursed costs, OOP costs, and loss of productivity were NT\$126,938, NT\$218,453, and NT\$327,741, respectively, per patient with mild, moderate, and severe AD. The total costs of AD in Taiwan, computed by multiplying the direct costs per patient by the number of patients with AD and adding the total costs associated with productivity loss across all patients with AD of working age, were estimated to be NT\$37.90 billion, equivalent to approximately 0.207% of Taiwan's gross domestic product (GDP) for 2018 (Taiwan's GDP in 2018 was NT\$18342.89 billion) (22). AD accounted for a larger proportion of GDP than psoriasis, which is a less prevalent skin disease. In 2009, the annual total costs of psoriasis, without accounting for the costs associated with presenteeism, were estimated to be equivalent to approximately 0.013% of Taiwan's GDP (23). These findings indicate that AD places considerable economic burdens on patients, families, the national healthcare system, and society.

#### *Atopic dermatitis-associated economic burdens in Taiwan compared with other countries*

A 3-month prospective study from South Korea estimated that the annual total costs of AD at the national level, including both direct and indirect costs, was South Korean won (KRW) 5.8 trillion, representing approximately 0.35% of South Korea's GDP in 2015 (12). The higher percentage of GDP associated with AD may be due to the higher prevalence of AD in South Korea (29.2%) compared with Taiwan. In addition, the South Korean study used a small sample size ( $n=38$ ), and differences in socioeconomic status may have contributed, as all of the patients in the South Korean study were enrolled from university hospitals. Another comprehensive study conducted in the US in 2002 calculated the total AD-related costs of mild, moderate, and severe AD to be US\$435.35, US\$578.79, and US\$3,229.05 per patient, respectively, which accounted for 1.1%, 1.5%, and 8% of the US GDP per capita in 2002 (US's GDP per capita in 2002=US\$38,023.20) (24). In the current study, the total AD-related costs associated with mild, moderate, and severe cases were 16.09%, 27.69%, and 41.55% of Taiwan's GDP per capita in 2018, respectively (Taiwan's GDP per capita in 2018= US\$25,792) (25).

### Study limitations

This study has several limitations. First, to calculate the overall costs, the study combined data from the NHIRD and questionnaire, which utilized differing strategies for classifying severity. Only 200 patients, aged 20 years and older, completed the study questionnaires, which may not be a representative sample of the total AD population in Taiwan. This may result in underestimation of the costs associated with work loss, by not capturing the lost productivity of caregivers for children with AD, who represent a substantial portion of the AD population. In addition, impaired quality of life and comorbidities may confer additional economic burden. However, both were difficult to quantify and were incorporated consistently into the current findings when direct costs were estimated using National Health Insurance database with no information on quality of life, whereas productivity loss and out-of-pocket costs were estimated using patient interview data with incomplete information on comorbidities. Furthermore, recall bias is an inevitable risk associated with the use of self-reported questionnaires and interviews.

### Conclusion

AD imposes a significant financial burden, costing an estimated NT\$37.90 billion in 2018, representing approximately 0.207% of Taiwan's GDP. In addition to the considerable burden placed on the NHI system, OOP costs and costs associated with the loss of work productivity are large contributors to the burdens placed on patients and their families. These costs should not be overlooked when evaluating and managing this disease. This substantial economic burden also indicates an existing need for the development of more effective and equitable AD treatments.

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*The authors have no conflicts of interest to declare.*

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