

Original article

Direct medical costs associated with atopic diseases among young children in Thailand

Jarungchit NgamphaiboonPediatric Department, Faculty of Medicine,
Chulalongkorn University, Bangkok, Thailand**Thitima Kongnakorn**

United BioSource Corporation, Bangkok, Thailand

Patrick Detzel

Nestle Nutrition Institute, Vevey, Switzerland

Krittawan Sirisomboonwong

Nestle (Thai) Ltd, Bangkok, Thailand

Radek Wasiak

United BioSource Corporation, London, UK

Address for correspondence:Thitima Kongnakorn, PhD, United BioSource
Corporation, 2/018 Changwattana Rd,
Toongsonghong, Laksi, Bangkok, Thailand 10210.
Tel.: 66-81-753-0092; Fax: 66-2-574-5546;
thitima.kongnakorn@unitedbiosource.com**Key words:**Atopic disease – Cow's milk allergy – Atopic
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Study of Asthma and Allergies in Childhood; KOL, Key
opinion leader; pHF, Partially hydrolyzed formula; THB,
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Citation: J Med Econ 2012; 1–11**Abstract****Objective:**

Allergic diseases are the most common childhood illness in Thailand. Their prevalence has been rising over time, with several studies having revealed substantial economic burden. However, no such study had yet been conducted for Thailand. The aim of this study was to estimate direct medical costs associated with atopic diseases among children aged 0–5 years in Thailand.

Research design and methods:

A cost-of-illness model was constructed to estimate the total direct medical costs of atopic diseases comprising atopic dermatitis, chronic rhinitis, asthma (i.e., recurrent wheeze), and cow's milk allergy. The model employed a prevalence-based approach, considering a total number of atopic cases in 2010. Direct medical costs were estimated using a bottom-up analysis with the estimation of the quantity of healthcare resource use and the unit costs. Epidemiological data were obtained from literature and Thai surveys, whereas treatment unit costs were from either a hospital database or Thai standard cost list. Expert opinion informed type, frequency, and quantity of medical resources utilized. Key limitations included lack of data-driven evidences on severity distribution for this particular age group, indirect costs, and medical resource use associated with each condition.

Results:

Total direct cost was estimated to be THB 27.8 billion (US\$899 million). Treatments contributed largest to the total costs (46%), followed by inpatient care (37%), outpatient care (12%), and monitoring and labs (5%). Costs per treated patient were highest in cow's milk allergy (THB 64,383; US\$2077), followed by rhinitis (THB 12,669; US\$409), asthma (THB 9633; US\$312), and atopic dermatitis (THB 5432; US\$175).

Conclusion:

Atopic diseases in young children are associated with substantial burden in direct medical costs to Thailand. These costs can be diminished through nutritional intervention recognized to effectively decrease the incidence of atopic diseases.

IntroductionOver 25% of the pediatric population in the industrialized world is affected by allergic disorders¹. An estimated 35% of pediatric asthma cases, 46% of pediatric rhinitis cases, and 32% of pediatric eczema cases may be directly attributable to atopy². According to the 'allergic march' (i.e., natural history of atopic diseases), food allergy and atopic dermatitis typically appear at the early age of life, beginning between the first 3–12 months, and are common during the first 2 years of life³. Cow's milk was the most reported offending food in small children based on a survey in European countries⁴. The incidence of these syndromes is rising throughout the world, although regional differences are marked². According to the Thai version of the International Study of Asthma and Allergies in

Childhood (ISAAC) questionnaire, the results from the survey indicate that allergic diseases are perhaps the most common childhood illness in Thailand, and the prevalence of these conditions has been rising over time⁵. This finding is supported by a multi-country cross-sectional ISAAC study which also observed an increase in the prevalence of these allergies, with the more noticeable trend in Asia Pacific regions⁶.

From the economic perspective, atopic diseases have been shown to impose a substantial burden on healthcare costs. A study by Emerson *et al.*⁷ shows an annual burden of £48 million associated with atopic dermatitis among children aged 1–5 years old in 1996 in the UK (equivalent to US\$114 million, 2011 value). Storms *et al.*⁸ estimated an annual direct cost of allergic rhinitis of US\$3.4 billion in 1997 (~US\$5.8 billion, 2011 value). A study by Chew *et al.*⁹ estimated the total annual cost of asthma in Singapore to be US\$33.93 million in 1992–1993 value (~US\$66 million, 2011 value). In addition, Lai *et al.*¹⁰ estimated total per patient annual direct costs of asthma in the Asia Pacific region on average to be 13% of the gross domestic product per capita.

While there are several estimates of the cost of atopic diseases, none had yet been conducted for Thailand. The aim of this study was to estimate the direct medical care costs associated with atopic diseases among children aged 0–5 years old in Thailand.

Methods

A cost-of-illness model was constructed in Excel[®] to estimate the economic burden of atopic diseases in children aged 0–5 years on the healthcare system in Thailand. The model employed a prevalence-based approach, considering a total number of atopic cases in 1 year (i.e., 2010 in the present study). Only direct medical care costs were considered, as evidence on relevant indirect costs (e.g., productivity lost) or direct non-medical costs (e.g., transportation) are scarce. Direct medical costs were estimated using a bottom-up approach which involved the estimation of the quantity of healthcare resource use associated with atopic diseases and the unit costs of the resource use¹¹. Overall mean medical costs were determined by aggregating the costs for each type of utilization and weighting them by the number of uses per year and the percentage of patients expected to utilize each resource. The per-patient costs were then multiplied by the Thai atopic diseases population to determine the overall cost of illness.

Model structure

A schematic presentation of the model structure is shown in Figure 1. Atopic conditions considered in this model

included atopic dermatitis, chronic rhinitis, asthma, and cow's milk allergy (CMA). Direct medical costs for each condition were derived separately and then summed up to estimate total costs for the disease. Amount of medical resource use is highly dependent on the severity of the disease. Thus, within each condition, severity distribution was considered to allow a more refined estimation of the quantity of healthcare resource use. At the end of each branch in the diagram, the number and type of medical resources (i.e., treatments, monitoring and lab tests, outpatient care, inpatient care) used by individuals associated with each severity level for each particular condition were estimated. Then, the costs for each atopic condition were calculated by aggregating the costs of all types of resource use for each severity level and weighting them by the severity distribution. Children with CMA are normally presented with allergic manifestations. Thus, besides costs related to substitution of patient's milk diet with different nutrition to avoid sensitization with cow's milk protein, burden related to treatments of the presenting symptoms also contribute significantly to the overall costs. Symptoms presented with CMA included in the model were skin manifestation (i.e., dermatitis and urticaria), respiratory symptoms (i.e., rhinitis and asthma), gastrointestinal symptoms, and other symptoms (i.e., failure to thrive, anaphylaxis shock, and anemia). Resource use for each symptom was estimated based on severity level for each symptom. Then the previously described costing approach was used to obtain a cost for treating each of the symptoms. Costs for each symptom were weighted by the frequency and aggregated to estimate the overall costs associated with CMA. Although some of the symptoms of CMAs are similar to those in other atopic conditions considered in the model (i.e., dermatitis, rhinitis, and asthma), the costs associated with these symptoms were considered as part of CMA-associated costs, and presented separately.

Model inputs and data sources

Epidemiology

Prevalence rates and other epidemiology inputs (e.g., severity distribution, frequency of each presenting symptom associated with CMA) employed in the study are shown in Figure 1. Prevalence data for atopic dermatitis, chronic rhinitis, asthma (i.e., recurrent wheeze) and CMA were based on a retrospective study of 3502 unselected Thai children aged 0–5 years from April 2005 to March 2006¹². Frequency of presenting symptoms associated with CMA including skin manifestation, gastrointestinal symptoms, respiratory symptoms and others (i.e., anaphylactic shock, failure to thrive, anemia) were obtained from a review of medical records of 352 children with CMA over the past 10 years¹³. Regarding the severity

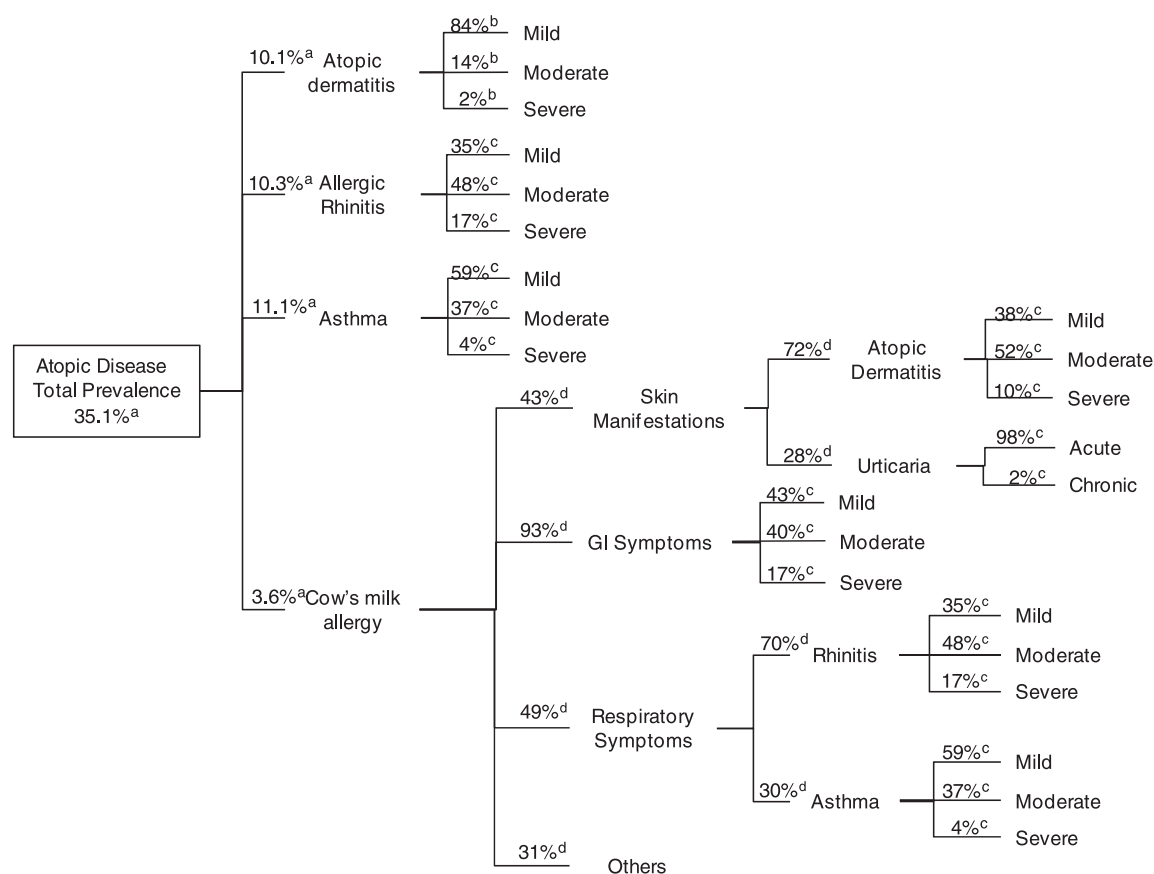


Figure 1. Schematic presentation of the model structure. (a) Ngamphaiboon *et al.*¹²; (b) Emerson *et al.*¹⁴; (c) Data on file, King Chulalongkorn Memorial Hospital, Bangkok, Thailand¹⁵; (d) Ngamphaiboon *et al.*¹³.

distribution, the distribution for atopic dermatitis was obtained from a study by Emerson *et al.*¹⁴, whereas those for chronic rhinitis and asthma as well as those for the symptoms associated with CMA were adopted from a survey among Thai children conducted by the researchers at the King Chulalongkorn Memorial hospital¹⁵. The questionnaires were developed by the team at the King Chulalongkorn Memorial hospital by modifying the well-known ISAAC study to accord with the Thai settings^{6,16–18}. In the study, severity levels were determined according to disease duration, intensity of clinical symptoms, and clinical signs based on clinical judgment. Due to lack of severity data in small children, severity grades of atopic dermatitis, chronic rhinitis, asthma, urticaria, and food allergy were collected from 26,350 Thai school children aged 6–18 years old and were assumed to be applicable to children in a younger age group¹⁵.

Medical resource use

Types of medical resources included were treatments, inpatient care, outpatient care, and diagnostic tests and monitoring. Information on Thai-specific type, frequency

of use, and quantity of medical resources for different severity level (i.e., mild, moderate, severe) by atopic condition was based on an interview with the key opinion leader (KOL). Expert opinion was used because national surveys and other available literature do not provide information on specific medical resources associated with the disease conditions of interest. Sensitivity analyses around these estimates were performed to test the robustness of the model results.

Treatments

Treatments associated with each atopic condition were obtained from the interview with the KOL. For chronic rhinitis, although treatment often begins with environmental control to reduce allergen exposure¹⁹, pharmacologic therapy is often required, especially for moderate-to-severe symptoms. With regard to atopic dermatitis, the symptoms can be controlled with a combination of moisturizers and pharmacologic treatments. For asthma, the goal of treatment is to keep symptoms under control all the time. For children diagnosed with CMA,

Table 1. Total costs reported by each atopic condition and resource use type (Thai baht).

	Cow's milk allergy	Atopic dermatitis	Chronic rhinitis	Asthma	Total
Treatment	8,341,687,056	1,196,131,898	2,817,077,750	332,018,553	12,686,915,258
Inpatient care	2,536,430,074	302,636,404	3,192,266,056	4,249,845,324	10,281,177,858
Outpatient care	950,664,178	901,069,644	610,167,031	932,432,025	3,394,332,879
Monitoring and lab tests	492,205,418	516,524,685	317,065,112	169,704,205	1,495,499,421
Total direct medical costs	12,320,986,726	2,916,362,632	6,936,575,950	5,684,000,107	27,857,925,415

treatments typically involve substitution of the current milk diet with different nutrition in addition to symptomatic treatments.

Monitoring and lab tests

Prick skin test and immunoglobulin E (IgE) blood test were common tests included across all atopic conditions. Additional tests included gastroscopy, colonoscopy, intestinal biopsy, pH monitoring, complete blood count, and stool culture, which were relevant specifically to the gastrointestinal symptoms of the CMA.

Outpatient care

Outpatient care considered included routine visits to pediatricians, specialists (i.e., allergist), and occasionally to the emergency department.

Inpatient care

Inpatient care included hospitalization and visits to the emergency department that led to inpatient admission.

Unit costs

Costs presented are in 2010 Thai baht (THB). Treatment unit costs were obtained from the Pharmacy Department at King Chulalongkorn Memorial Hospital. Costs of the nutrition to treat CMA included in the model were only the marginal costs to those of the current milk diet if the children did not have CMA. Unit costs of each resource use (i.e., physician visits, lab tests, hospitalization) were obtained from a Thai standard cost list developed specifically for health technology assessment²⁰.

Model inputs (unit costs and medical resource use) for each atopic condition are shown in the Appendix.

Sensitivity analysis

In order to account for uncertainty in the model, a probabilistic sensitivity analysis where key inputs including prevalence rates, costs, severity distribution, and quantity of resource use were varied simultaneously from replication to replication (i.e., 10,000 replications were run) by sampling from probability distributions was performed.

Proportions of patients utilizing each resource and proportions of severe cases among each atopic condition were varied randomly according to a beta distribution, while quantity of resource use, unit costs, and prevalence rates were varied according to a gamma distribution, assuming 20% standard deviations around the mean. Univariate deterministic sensitivity analysis was also performed in four key parameters: prevalence, quantity of resource use, unit costs, and, since severe cases are usually associated with highest costs compared to mild and moderate condition, proportion of severe cases. Each parameter was varied according to the 95% confidence intervals, assuming standard deviations were ~20% of the mean, while other variables were holding constant.

Results

By applying the prevalence rates of 10.1%, 10.3%, 11.1%, and 3.6% for atopic dermatitis, chronic rhinitis, asthma (i.e., recurrent wheeze), and CMA, respectively, to the number of Thai children aged 0–5 years in 2010 (i.e., 5,315,800), 536,896 cases of atopic dermatitis; 547,527 cases of chronic rhinitis; 590,054 cases of asthma; and 191,369 cases of CMA were identified.

Table 1 presents the total annual medical direct costs of atopic diseases for all four conditions, which were estimated to be THB 27.8 billion (US\$899 million). Treatments contributed largest to the total costs (46%), followed by inpatient care (37%), outpatient care (12%), and monitoring and lab tests (5%). Comparing the costs among the atopic conditions, CMA was associated with the highest costs (44% of the total burden), followed by chronic rhinitis (25%), asthma (20%), and atopic dermatitis (11%).

The average yearly medical cost of atopic diseases per patient is displayed in Table 2. CMA was associated with the highest per-patient annual cost (THB 64,383; US\$2077), with treatments accounting for the largest cost component (68%). Inpatient care accounted for 20% of the total direct costs, while outpatient care accounted for 8%. Monitoring and lab tests contributed only 4% of the total costs, but still represent total annual expenditures of close to THB 500 million (US\$16 million). The second most costly condition was chronic

Table 2. Average direct medical costs per treated patient (Thai baht).

	Cow's milk allergy	Atopic dermatitis	Chronic rhinitis	Asthma
Treatment	43,590	2228	5145	563
Inpatient care	13,254	564	5830	7202
Outpatient care	4968	1678	1114	1580
Monitoring and lab tests	2572	962	579	288
Direct medical costs (per treated patient)	64,383	5432	12,669	9633

rhinitis, with an estimated per-patient annual cost of THB 12,669 (US\$409). The majority of the costs were associated with inpatient care (46%) and treatments (41%). Costs of outpatient care and monitoring and diagnostic tests accounted for only 9% and 4%, respectively. Annual cost per child with asthma was estimated at THB 9633 (US\$312), slightly lower than the cost of chronic rhinitis. The main cost driver for asthma was related to inpatient care (75%), followed by outpatient care (16%), treatments (6%), and then monitoring and laboratory tests (3%). Atopic dermatitis was estimated with the lowest annual per-patient cost (THB 5432; US\$175). The average treatment cost that was the largest cost component, representing 41% of the total costs, was estimated at THB 2228 (US\$72). Outpatient care accounted for 31% and monitoring and diagnostic tests for 18%. Since atopic dermatitis is generally managed on an outpatient basis, inpatient care costs accounted for only 10% of the total costs.

Probabilistic sensitivity analysis revealed a 95% confidence interval of the total direct medical costs ranged from THB 22.1 billion (US\$712 million) to THB 29.7 billion (US\$957 million). In addition, the results from the univariate sensitivity analysis are graphically shown as a tornado diagram in Figure 2. In all scenarios, varying parameters to the lower bound of the 95% confidence interval resulted in a decrease in the total annual direct medical costs. Reciprocally, increasing the parameters to the upper bounds consistently increased the resulting total costs. The top three parameters that had the most influence on the total medical direct costs were the quantity of treatments used, treatment costs, and prevalence of CMA. Varying the amount of treatments consumed from the lower bound to the upper bound of its 95% confidence interval fluctuated the total direct costs from THB 23.4 billion (US\$754 million; decreased by 16%) to THB 33.3 billion (US\$1074 million; increased by 20%), respectively. Similarly, the total medical direct costs decreased to THB 23.4 billion (US\$756 million) and increased to THB 33.2 billion (US\$1072 million) when treatment costs were varied from the lower to the upper bounds of its 95% confidence interval. Lowering the prevalence of CMA to the lower bound (i.e., 2.3%) was associated with a decrease in the total direct costs to THB 23.4 billion (US\$755 million), whereas the total direct costs increased

to THB 33.0 billion (US\$1064 million) when the prevalence increased to 5.1%.

Lowering the average quantity use of inpatient and outpatient care to the lower bound decreased the total direct costs by 13% and 4%, respectively, while increasing the average quantity to the upper bound increased the total direct costs by 16% and 5%. Varying the average quantity use in monitoring and lab tests had the smallest impact compared to variations in the inpatient care, outpatient care, and treatments utilization. This resulted in the change from -2% (negative sign indicates a decrease in the total costs from base case) to 2%.

Variation in inpatient and outpatient care costs is shown to have a relatively moderate effect on the total direct costs. Decreasing unit costs of inpatient care (i.e., hospital per diem cost) and outpatient care (i.e., cost per visit) resulted in reduction in the total costs by 13% and 4%, respectively. An increase in inpatient or outpatient care unit costs resulted in an increase in the total costs by 14% and 5%, respectively.

Regarding the prevalence, whereas varying the input on prevalence of CMA had substantial impact on the results, smaller impacts are observed when varying prevalence of chronic rhinitis (i.e., total costs were varied by -9% to 11% for lower and higher prevalence, respectively), followed by that of asthma (by -7% to 9%) and atopic dermatitis (-4% to 4%), respectively.

The results from the base case have shown that the cost of monitoring and lab tests contributed to only 5% of the total direct cost. Variation in the unit cost of monitoring and lab tests over the 95% confidence interval slightly affected the total direct cost, resulting in the changes of up to 2% compared to base case results.

Although severe cases are associated with highest cost compared to illness with milder severity, varying the proportion of severe cases in each atopic condition had shown only a limited impact to the total costs. Varying this parameter for each atopic condition resulted in a decrease or an increase in the total costs by only up to 3% compared to the base case.

Discussion

Atopic diseases impose a substantial burden on healthcare resources in Thailand as shown by the results from

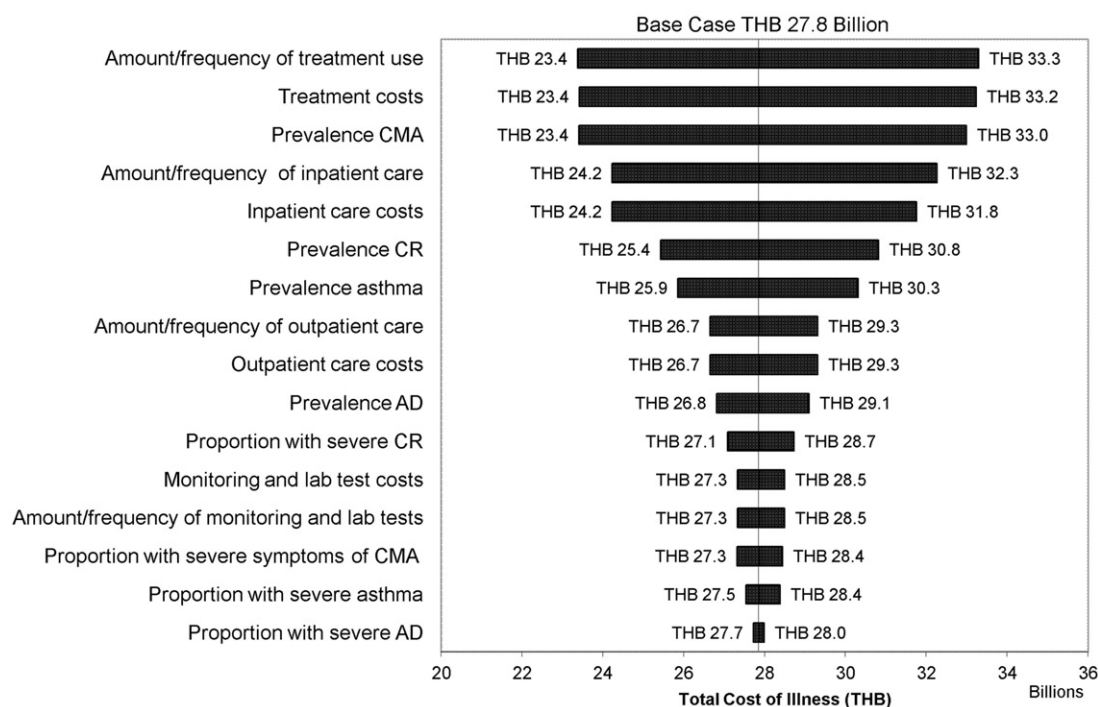


Figure 2. Tornado diagram of the sensitivity analyses. The solid vertical line represents the base-case annual direct medical costs. Horizontal bars indicate the range of the total costs obtained by setting each variable to the lower bounds (left hand side) and upper bound (right hand side) of the 95% confidence interval for each variable while holding all other values constant. CMA, cow's milk allergy; CR, chronic rhinitis; AD, atopic dermatitis, THB, Thai baht.

this study. This study focused on children aged 0–5 years old; in this age group high burden was expected as, besides symptomatic treatments, nutritional interventions are recommended. The model estimated that the total medical direct costs in managing atopic diseases in children aged 0–5 years old in Thailand were ~THB 27.8 billion (US\$899 million) in 2010, ~5% of the 2010 Thailand total healthcare expenditure of US\$18.9 billion, as reported by the Ministry of Public Health²¹. At an individual level, the burden from this illness posed an average annual per patient cost ranging from US\$175 (i.e., atopic dermatitis) to US\$2077 (i.e., CMA), representing up to 24% of the average annual household income in Thailand²². The cost of this illness would continue rising with the growing prevalence of the disease over time, as indicated in past studies^{2,5}. Treatments for these atopic conditions are mostly for symptom control and preventive maintenance (i.e., to prevent relapse), thus they likely require long-term use and are associated with high accumulated costs. As shown in the results, among the cost components, treatments contributed largest to the total medical direct costs (46%). The second largest cost component was related to inpatient care, which contributed 37% of the total direct costs. The majority of the inpatient care costs were contributed from the respiratory-related conditions (i.e., chronic rhinitis and asthma), as these conditions are associated with

higher likelihood of hospitalization, especially among a pediatric population.

CMA, although associated with the lowest prevalence compared to the other conditions, has been shown to be the major cost driver, contributing 44% of the total costs. Any strategy that can decrease the risk of atopic diseases would considerably reduce the country's healthcare expenditure.

Breast feeding is the gold standard for milk feeding in infant nutrition, and exclusive breast feeding is recommended for at least the first 4 months of life²³. A recent Thai study has shown a lower incidence of atopic diseases in exclusively breast-fed infants compared to cow's milk-based formula-fed infants¹². In the same Thai study, partially hydrolyzed formula (pHF) given in the first 4 months of life has shown a strong preventive effect associated with significantly lower occurrences of atopic diseases (i.e., AD, chronic rhinitis, CMA, asthma) compared to those on cow's milk-based formula (i.e., 11.3% vs 42.3%). Similar findings were observed in meta-analyses of the prospective controlled trials of a pHF which showed a significant preventive effect of the pHF on the development of allergic symptoms^{24,25}. Extensive hydrolyzed formula (eHF), another preventative approach, also showed comparable outcomes to the pHF^{25,26}. However, although the preventative effect for pHF and eHF are similar, the cost of eHF is typically higher, thus one can expect it to be less

cost-effective than the pHF. In addition, the poorer taste of the eHF might be an issue for compliance.

The savings in the country's healthcare expenditure associated with each avoidance of atopic diseases resulting from any preventive strategy such as pHF and eHF can be much more significant than the annual costs reported in this study when taking into account the long-term impact of the disease. Atopic diseases are long-term conditions in nature, and, thus, the actual healthcare costs will likely accumulate beyond 1 year.

One point worth mentioning concerns the findings from this study which indicate that atopic dermatitis was associated with relatively low direct medical costs. However, this may not be the case in other Western countries due to the fact that the management of atopic dermatitis in Thailand can be fairly different from the Western countries, mainly due to the difference in climate zones. Thailand is in a tropical zone with warm weather and high humidity, thus the degree of treatments required to treat skin problems tend to be less than those in the Western countries with dry and cold weather. Cost savings associated with any preventive strategy such as pHF in Thailand are expected to be highlighted rather in other conditions, specifically, chronic rhinitis and asthma which are most prevalent, as well as the costly condition, CMA.

Comparisons of the estimated costs across atopic conditions should be made with caution. The results showed that CMA was associated with the highest direct medical costs, with treatments representing 68% of the total costs. Approximately 90% of the treatment costs were due to the costs of nutritional intervention which contributed to an average annual cost of THB 38,160 (US\$1231) per patient. Costs reported for CMA were based on the prevalence cases with a confirmed diagnosis of CMA, thus guaranteed a treatment of milk's diet change, while only classical drug-related interventions were taken into account in the treatment costs for atopic dermatitis, chronic rhinitis, and asthma. This partly explains their relatively low costs compared to the costs of CMA. Although treatments for atopic dermatitis, rhinitis, and asthma in young children can involve change in the current milk diet, these cases were already captured under CMA (e.g., 43% of patients with CMA presented with skin manifestations and 72% of those were atopic dermatitis; 93% of patients with CMA presented with respiratory symptoms, 70% were rhinitis and 30% were asthma). Thus, to consider the total cost associated with atopic dermatitis, rhinitis, or asthma, one may want to take into account the additional costs of nutritional intervention for cases that fell under CMA, which were subjected to an additional THB 38,160 (US\$1231) per patient.

Another potential concern related to the data inputs are the unit costs for drugs and products used as treatments for the atopic conditions. These costs were based on the prices obtained from the Pharmacy department of the King

Chulalongkorn Memorial hospital. The King Chulalongkorn Memorial hospital is a public hospital and also serves as a teaching hospital of the Faculty of Medicine, Chulalongkorn University, one of the largest universities in Thailand. Their prices tend to be lower than other public hospitals and much lower compared to those from the private hospitals and clinics. Thus, the results from this study are considered to be on the conservative side.

The results of this study should be interpreted with caution. An assumption was made that all patients in the country had access to healthcare and were provided appropriate care, which in fact might be true only in the urban areas. The assumption made was based on one of the goals in Thai health system reform from 2001; i.e., to provide healthcare access to everyone. According to the expert opinion, currently only ~50% of these children have access to and will seek out appropriate care, but with the ongoing reforms and increased access to care, the percentage will likely grow fast. Thus, although the current actual healthcare expenditure estimate may not be as high as reported here it will likely reach that level in the long run.

Other limitations have to be acknowledged. First, severity distributions in most of the atopic conditions were based on a Thai survey among children aged 6–18 years old¹⁵. An assumption was made that the same distributions would be observed among small children. The results from the sensitivity analysis by varying proportion of severe cases (i.e., severe cases are associated with highest costs compared to mild and moderate disease) showed that severity distribution had only a limited impact to the total direct medical costs. Secondly, this study did not include indirect costs (i.e., work days or productivity lost for parents to watch over sick children) and non-medical direct costs (i.e., transportation to healthcare facility) as the evidence in Thailand was not available at the time of the study. Cost of illness studies from other countries had revealed a significant proportion of these costs among total cost of illness for this disease. Studies for the US and some Asian countries reported ~50% of total costs associated with atopic dermatitis and asthma are indirect costs^{27–30}, whereas a Korean study reported indirect costs to be 19% of the total cost of allergic rhinitis³¹. Had these costs been included in the present study, the burden of atopic diseases from a societal perspective would have been increased by ~50% (THB 42.2 billion; US\$1361 million). Lastly, although the inputs on the quantity of healthcare utilization employed was based on the expert opinion, as the published evidences were scarce, these estimates were varied in the sensitivity analyses, and the ranges of the results have been reported. In the most conservative scenario where the quantities of treatment utilized were varied to the lower bound, the total direct costs were estimated at THB 23.4 billion (US\$754 million). Compared to the total healthcare expenditure in

2010, this estimate represented 4% of the total expenditure, slightly lower than the base case estimate (i.e., 5%).

Despite these limitations, the study has significant strengths. As healthcare resource utilization is highly dependent on the severity of the illness, detailing the structure of the model by the inclusion of severity level for each condition allowed a more refined estimation of the quantity of healthcare resource use and thus provided a more accurate estimate of the overall results. Furthermore, unit costs of the healthcare resource employed in this study were based on standard unit costs of medical services in Thailand which were developed specifically for health economic evaluation in Thailand by the Health Intervention and Technology Assessment Program (HITAP)²⁰. Thus, the unit costs of medical services (i.e., inpatient and outpatient care, lab tests) employed in this study appropriately represent national costs in Thailand.

Conclusions

Atopic diseases in children aged 0–5 years old are associated with substantial burden in direct medical care costs to Thailand. Much of these costs can be diminished through nutritional intervention clinically proven to effectively decrease the incidence of atopic diseases, especially among children with high risks. pHF and eHF have been shown to significantly reduce the risks of allergic diseases in children up to 4 years of age compared to children fed with standard infant formula^{12,25}. They can thus be considered as an alternative for high-risk infants to prevent the development of atopic diseases.

Transparency

Declaration of funding

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Declaration of financial/other relationships

TK and RW are employees of United BioSource Corporation which was a paid consultant to Nestle Nutrition Institute in connection with the development of the manuscript. PD is an employee of Nestle Nutrition Institute. JN was paid by Nestle (Thai) Ltd for an involvement in the study as a key opinion leader and the participation in the development of the manuscript. KS is an employee of Nestle (Thai) Ltd.

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Appendix: Unit costs and medical resource use associated with each atopic condition

Table A1. Medical resource use associated with atopic dermatitis.

Medical resource	Unit costs (THB)	Average numbers of units utilized per year			% Patients receiving		
		Mild	Moderate	Severe	Mild	Moderate	Severe
<i>Treatment</i>							
Moisturizer	180.00	2	4	6	100%	100%	100%
Soap	600.00	—	2	4	—	100%	100%
Steroid cream	60.00	2	5	8	50%	70%	80%
Tacrolimus ointment	1273.00	—	2	5	—	30%	70%
Antihistamine	204.00	10	15	24	50%	70%	100%
Antifungus	47.00	—	2	4	—	10%	20%
Antibiotics	343.00	—	2	4	—	30%	60%
Prednisolone	20.00	—	2	3	—	20%	40%
<i>Inpatient care</i>							
Hospitalization	6263.09	—	1	2	—	50%	50%
<i>Outpatient care</i>							
Pediatrician visit	351.46	4	3	5	100%	100%	100%
Specialist visit	374.56	—	5	7	100%	100%	100%
<i>Lab tests</i>							
Prick skin test	500.00	1	—	—	100%	—	—
Blood test	3387.86	—	1	1	—	100%	100%

Table A2. Medical resource use associated with chronic rhinitis.

Medical resource	Unit costs (THB)	Average numbers of units utilized per year			% Patients receiving		
		Mild	Moderate	Severe	Mild	Moderate	Severe
<i>Treatment</i>							
Intranasal glucocorticosteroids	705.00	2	3	5	20%	30%	40%
Antihistamine	204.00	10	15	25	100%	100%	100%
Montelukast	27.00	–	120	210	–	50%	70%
<i>Inpatient care</i>							
ED	4701.01	–	1	2	–	30%	50%
Hospitalization	10,438.48	–	1	2	–	30%	50%
<i>Outpatient care</i>							
Pediatrician visit	351.46	3	4	1	50%	60%	70%
Specialist visit	374.56	–	2	6	50%	60%	70%
<i>Lab test</i>							
Prick skin test	500.00	–	1	1	–	50%	10%
Blood test	3387.86	–	1	1	–	10%	50%

ED, Emergency department.

Table A3. Medical resource use associated with asthma.

Medical resource	Unit costs (THB)	Average numbers of units utilized per year			% Patients receiving		
		Mild	Moderate	Severe	Mild	Moderate	Severe
<i>Treatments</i>							
Inhaled glucocorticosteoids	282.00	—	2	4	—	30%	40%
Montelukast	27.00	—	120	210	—	30%	50%
Prednisolone	20.00	—	1	2	—	100%	100%
<i>Inpatient care</i>							
ED	4701.01	—	1	3	—	60%	80%
Hospitalization	10,438.48	—	1	3	—	60%	80%
<i>Outpatient care</i>							
Pediatrician visit	351.46	4	1	—	40%	20%	—
Specialist visit	374.56	—	4	4	—	40%	50%
ED	4701.01	—	3	5	—	15%	20%
<i>Lab tests</i>							
Prick skin test	500.00	—	1	1	—	50%	10%
Blood test	3387.86	—	1	1	—	10%	50%

ED, Emergency department.

Table A4. Medical resource use associated with cow's milk allergy.

Medical resource	Unit costs (THB)	Average numbers of units utilized per year			% Patients receiving		
<i>Nutritional intervention^a</i>							
Soy formula	150.00 ^b	120			20%		
pHF	130.00 ^b	120			20%		
eHF	190.00 ^b	120			50%		
Amino acid formula	1670.00 ^b	120			10%		
<i>Outpatient care^a</i>							
Pediatrician visit	351.46	4			30%		
Specialist visit	374.56	7			70%		
<i>Lab tests^a</i>							
Prick skin test	500.00	1			41%		
Blood test	3387.86	1			25%		
<i>Atopic dermatitis^c</i>							
Treatment		Same as in Table A1			Same as in Table A1		
Inpatient care		Same as in Table A1			Same as in Table A1		
Outpatient care		Mild	Moderate	Severe	Mild	Moderate	Severe
Pediatrician visit	351.46	0	0	1	—	—	100%
<i>Urticaria^c</i>							
Treatment		Acute	Chronic		Acute	Chronic	
Antihistamine	204.00	4	25		100%	100%	
Prednisolone	20.00	20	—		17%	—	
<i>Inpatient care</i>							
ED	4701.01	1	—		50%	—	
Hospitalization	6263.09	1	—		50%	—	
<i>Outpatient care</i>							
ED	4701.01	2	—		20%	—	
<i>Rhinitis^c</i>							
Treatment		Same as in Table A2			Same as in Table A2		
Inpatient care		Same as in Table A2			Same as in Table A2		
<i>Asthma^c</i>							
Treatment		Same as in Table A3			Same as in Table A3		
Inpatient care		Same as in Table A3			Same as in Table A3		

(continued)

Table A4. Continued.

Medical resource	Unit costs (THB)	Average numbers of units utilized per year			% Patients receiving		
Outpatient care		Mild	Moderate	Severe	Mild	Moderate	Severe
ED	4701.01	–	3	5	–	15%	20%
GI symptoms^c		Mild	Moderate	Severe	Mild	Moderate	Severe
<i>Treatment</i>							
Antibiotics	282.00	–	2	3	–	9%	9%
Prednisolone	40.00	–	1	2	–	9%	9%
Blood transfusion	948.95	–	2	2	–	2%	2%
<i>Inpatient care</i>							
ED	4701.01	–	1	2	–	50%	80%
Hospitalization	14,613.87	–	1	2	–	50%	80%
<i>Outpatient care</i>							
ED	4701.01	–	2	4	–	50%	80%
<i>Lab tests</i>							
Gastroscope	3929.37	–	1	2	–	20%	30%
Colonoscopy	3116.98	–	1	2	–	20%	70%
Intestinal biopsy	3713.47	–	1	2	–	20%	70%
Ph monitoring	300.00	–	1	1	–	5%	15%
Blood test	121.56	–	1	1	–	50%	80%
Culture (Stool)	202.84	–	2	3	–	60%	80%
Other symptoms^c							
<i>Treatment</i>							
Epinephrine (for anaphylactic shock)	100.00		4			2%	
Multivitamins (for failure to thrive)	180.00		6			77%	
Iron Sulfate (for anemia)	61.00		12			20%	
<i>Inpatient care</i>							
ED	4701.01		3			2%	
Hospitalization	10,438.48		3			2%	
<i>Outpatient care</i>							
ED	4701.01		1			3%	

pHF, partially hydrolyzed formula; eHF, extensively hydrolyzed formula; ED, Emergency department; GI, Gastrointestinal.

^aApply to all patients with cow's milk allergy.

^bMarginal cost to the current milk diet.

^cApply to patients with cow's milk allergy who present with this symptom.