

Cost Effectiveness of Emollients in the Prevention of Relapses in Atopic Dermatitis

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Introduction: Atopic dermatitis (AD) is chronic inflammatory skin condition, characterized by its remission-relapse cycles. This predominantly pediatric disease is becoming more and more prevalent. Emollients are part of the therapeutic management and particularly a way to increase time between relapses. The follow-up of AD and relapses have a great impact on patient's quality of life, expenditures and society costs. The aim of this study is to assess the cost-effectiveness of different emollients prescribed to AD patients.

Methods: A three-state Markov simulation model was developed over a six-year period with 28 days cycles. Two perspectives were adopted, a health care system perspective and a societal perspective. Four different emollients (A, B, C, D) were compared with no emollient use. Time without flare-up was the key endpoint of the study. Quality adjusted life-years (QALYs) were assessed as a secondary outcome. Cost and effectiveness data were derived from (i) randomized clinical trials and literature review for the efficacy of treatments, (ii) resource utilization and quality of life data, and (iii) unit prices from official price lists.

Results: The six-year health care costs associated with emollient A amount to £1844.23 and generate 4.58 years-without flare-up. Compared to emollient B, emollient A is costlier (Δ £41) but more effective (0.097 years). The ICER is £428.30 per year without flare-up. Emollient A is the dominant strategy compared to no treatment (£2,251.01; 3.99 years without flare-ups). When accounting for the societal costs, emollient A is the dominant strategy.

Discussion: According to the analysis, treatment with preventive emollient was a cost-effective option compared with no treatment in adult AD patients. In this comparative study, emollient A is the most efficient strategy from a willingness to pay £200 with a probability of 49%.

Keywords: atopic dermatitis, cost-effectiveness, Markov model

Introduction

Atopic dermatitis (AD) is an inflammatory skin condition affecting between 5 and 20% of children.¹ This disease mostly recovers by itself at adulthood in 85% of cases. In industrialized countries, prevalence of AD has tripled in the last 30 years. Given the air pollution, incidence will not decrease, and this disease will continue to be a burden.

AD is a chronic, remitting-relapsing, pruritic, inflammatory, immune-mediated skin condition. Skin may be red and inflamed (erythema), thickened and leathery (lichenification) and dry (xerosis) with scaly plaques, bleeding, oozing, cracking and flaking. Itching (pruritus) is the most disruptive symptom. It may be unrelenting, frequent and intense, affecting sleep and causing anxiety or depression.²

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Itching may also affect work performances and learning abilities having a tremendous impact on one's quality of life.

AD is characterized by its relapse-flare-up cycle: a period nearly symptom free is followed by an acute inflammatory flare-up where the patient needs to use corticoids to soothe the inflammation.

AD relapses are prevented by the daily use of moisturiser.³⁻⁵ Thus, NICE recommends moisturisers as the first-line of treatment in delaying flare-ups, and corticoids to treat acute phases.⁶ Nevertheless, this therapy aims only to manage the symptoms. It improves quality of life by decreasing the frequency and the intensity of flare-ups, the number of visits to a doctor, and the loss of productivity.

The scoring of atopic dermatitis (SCORAD), is an assessment tool of AD. It combines extent, severity and subjective symptoms of the disease. This tool is used by physicians to determine whether a treatment, in our case an emollient, has been effective in soothing AD symptoms.

While a collection of emollient floods the market, their efficiency is not well known. To our knowledge few cost-effectiveness studies have been published and none were comparing an overall set of emollients.^{7,8}

The aim of the study is to assess the cost-effectiveness of four emollients (A, B, C, D) on AD relapses. It will consider the health results as well as the cost of intervention for the health system.

Methods

A cost effectiveness study was design. Two dermocosmetic emollients (A and D) are compared to a mass-market emollient (emollient B), to an emollient medical device (MD) (C) and to no emollient (composition of emollients (INCI) in [supporting information](#)). The base case scenario was completed with deterministic sensitivity analyses (DSA), probabilistic sensitivity analysis (PSA) and scenario analyses.

All statistical analyses were performed using Microsoft Excel version 16.0 for Office 365.

Analytical Framework

The model was based on patients' data extracted from a randomized controlled trial (RCT).⁹ Ninety-nine patients aged six months and older with mild AD were recruited in this trial. The mean age was 11.5±12.6 years old. 26.3% of them were aged 16 and more. More than half (56.6%) were female, reflecting the sex ratio of the disease.

Population from other RCT's similarity regarding age and sex was assessed. As no differences were found between populations, patients were modelled from this RCT.⁹

As AD is a chronic disease, a three states Markov model was implemented to mimic the course of the disease: "flare-ups", "postcorticoid", "maintenance" (Figure 1). Patients in the maintenance or postcorticoid states are considered to have mild AD according to their SCORAD score and moderate AD when they are in the flare-up state—this stage is defined by a degradation of SCORAD score >20%.

Modelled patients enter the model in the postcorticoid stage. In this stage: either the patient can relapse, or they can enter the maintenance stage. Once the patient enters the flare-up stage it is assumed that the patient will use corticosteroids, at the end of the cycle the patient will automatically transition to the postcorticoid stage.

A literature review from van Zuuren et al⁵ reported 15 RCTs assessing survival before flare-ups. The authors assessed quality of the study as well according to their risk of selection bias, detection bias, attrition bias, and reporting bias. Using data from this review we defined transition probabilities. When the RCT lasted for a different time frame than the published RCT,⁹ we used the DEALE (Declining Exponential Approximation of Life Expectancy) method¹⁰ to compute transition probabilities.

The main assumption in the construction of this model is the equality of the transition probabilities between the maintenance state and the flare-up state (Mf) and between the postcorticoid state and the flare-ups state (Pf). Thus the three health states model could be assimilated to a two health states model, similar to the one found in the literature.^{7,8} However, the three health state model is more comprehensive while integrating a seasonal effect, or a rebound effect. This hypothesis is motivated by the lack of data in the literature, which mention only the Pf probabilities. The heterogeneity of patient care according to the severity of AD led to the adoption of this assumption with support of expert opinion. While there is evidence of seasonal reductions of flare-up probability during the summer this reduction has not been quantified yet. Therefore, we could not take it into account in the model (Table 1).

Four moisturisers were compared. INCI (International Nomenclature of Cosmetic Ingredients) composition of different comparators are available in [supporting information](#).

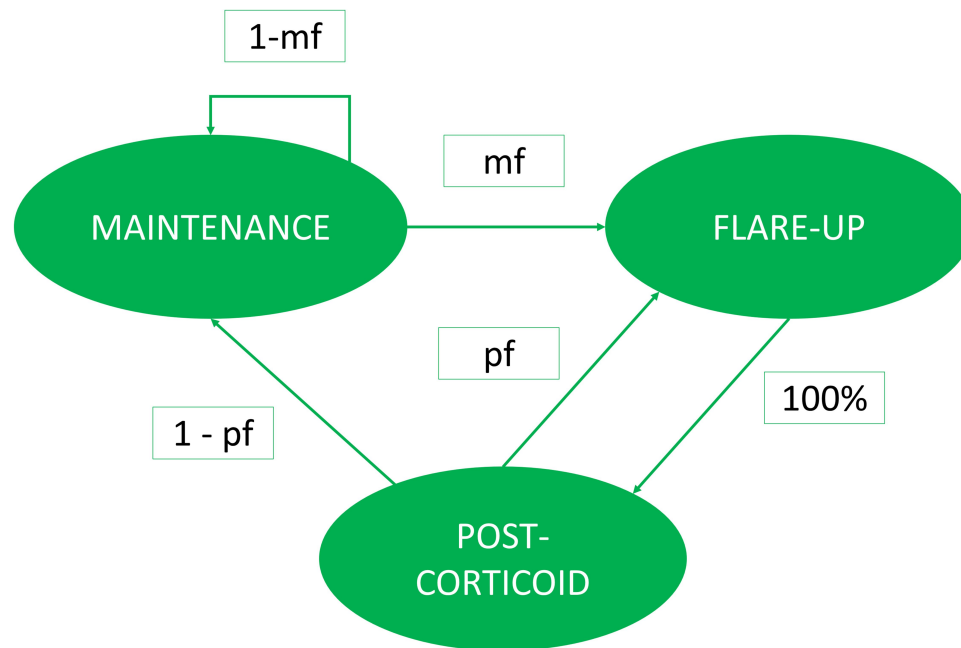


Figure 1 Markov model used to model cost-efficiency of different emollients.

Notes: Pf, probability to enter the flare-up state from the postcorticoid state; 1-Pf, probability to enter the maintenance state from the postcorticoid state; Mf, probability to enter the flare-up state from the maintenance state; 1-Mf, probability to stay in the maintenance state.

Emphasis will be put on comparison of the most effective emollient (A) to a mass-marketed emollient (B) and no treatment options. Nevertheless, two other emollients, an emollient MD status (C) and another dermocosmetic (D) were used in the comparison.

A six-year time horizon was selected for the base-case scenario. A meta-analysis reported a mean duration of AD persistence of 6.1 years.¹¹ The studied population will consist of adults and children. Hence, we must consider that the treatment will not be taken for life. The RCT used to model the transition probabilities lasted for four weeks or 28 days, consequently we chose to use cycle of 28 days. A half cycle correction was applied.¹²

Table 1 Transition Probabilities

Emollient	Conversion Method	Mf
Emollient A ⁹	Directly from the Kaplan–Meier curve of RCT	18.00%
No moisturiser ¹⁶	DEALE	35.73%
Emollient B ¹⁶	DEALE	20.56%
Emollient C ¹⁶	DEALE	28.38%
Emollient D ¹⁵	Directly from the Kaplan–Meier curve of RCT	32.00%

A discount rate of 3.5% was applied to efficacy and costs, following NICE recommendation.¹³

Efficacy

Efficacy of different treatments was derived from randomized controlled trials.^{9,14–16} Time without relapse was used as the marker of effectiveness. Time without relapse was defined as the time each patient spent in a different state than flare-up. ECLA study reports a utility of 0.79 for mild AD, and 0.68 for moderate AD.¹⁸ These utilities will be used in the model to compute the efficacy of treatments in a complementary analysis. Time without relapse was deemed more appropriate for the study of AD than quality adjusted life-years (QALY). Indeed, while QALY are a great tool to measure the impact on the medical quality of life, time without flare-up describes more accurately the daily life of the patient, their comfort, and relationship toward the disease. Furthermore, using time without flare-up (TWFU) or years (YWFU) as a measure, we can only rely upon our model, without resorting to use an external clinical trial (ECLA study).

Costs

The costs used in the base-case model were the treatment costs: emollients, corticosteroids, hospitalization costs, follow-up costs (medical consultations) and other out-of-pocket

expenditures. Due to the route of administration of the treatment, no administration costs were added.

It was impossible to use the NHS perspective, as the comparators are not all reimbursed yet by the public health insurance. Indubitably, it would have been questionable to exclude the costs of comparators in the comparisons. Therefore, a health system perspective was adopted. The health care system perspective includes all direct costs such as; treatment costs (both preventive and curative), consultations costs, hospitalization costs, and out-of-pocket expenditure specifically: clothes, bandages, hygiene products, sun protection, and food supplements. In the societal perspective we added an indirect cost of the disease in terms of productivity losses.

Prices were corrected for inflation using the health component of the Consumer Price Index.¹⁷ It was 2.91% from 2018 to 2019 and 5.24% from 2017 to 2019. Cost of moisturisers was derived from NHS prescription cost analysis 2017 and 2018.^{18,19} Cost of treatment was obtained from the mean daily use of a moisturiser^{9,15,16} and its price (Table 2).

During flare-ups, treatment consists of application of topical corticosteroids. Åkerstrom et al²⁰ reported a mean quantity of 5.9 g per application. Guidelines in good use of topical corticosteroid demands a total of 20 applications per cycle. To remain agnostic toward which steroid was used, the mean price weighted by the prescription rate of the top 10 topical corticosteroids used in the UK was computed from the NHS prescription cost analysis^{18,19} and a price of £0.103/mL was used.

Beside the cost of treatment, other costs were included in the analysis. Other medical costs such as hospitalization and visit to different doctors (general practitioners (GPs) and/or specialists) were accounted for as well. Health-care utilization was extracted from the dupilumab appraisal; in flare-up state, on average a patient visits a GP 1.363 times, and a specialist in an outpatient visit 0.579 times. Costs were derived from personal social service,²¹ and national tariff payment.²²

The ECLA study revealed that 1.80% of patients suffering from AD were fully hospitalized almost twice

a year, and 0.40% were in a one-day hospitalization.²³ Costs of hospitalization were derived from disease related groups: AD correspond to JD07K in the national tariff payment system and amounts to £423 a day (Table 3).²²

The ECLA study showed that patients did not buy the same alleviating products: food supplements, cotton clothes, bandages, whether they were in mild or moderate AD. It was used to estimate the out-of-pocket expenditure of patients suffering from AD (Table 4).²⁴

In a complementary analysis, we changed the perspective and took all expenditure into account. We added the cost of productivity loss in a societal perspective. AD can lead to hospitalization and may impair work performance with the constant and debilitating itching. When the patient is a child, we assume that the productivity loss was from the caring parent who could not work while nursing their child. The ECLA study was used to assess the frequency of sickness leaves. The human capital method was used to account for the costs of productivity loss. We accounted both for sick leave in general and time spent in the physician's waiting room.²⁵

Results

Efficacy

Emollient A is the most effective strategy as shown in Table 5. Patients using this emollient will have 4.58 years without flare-up (YWFU) over a six-year period. It is 0.097 YWFU more than the emollient B and 0.60 YWFU more than no moisturiser. Although the difference is low, emollient A is more effective: 59.75 cycles in maintenance state, while it is 58.49 cycles for emollient B. These 1.26 cycles difference amounts to almost 35 days—improving the patient's quality of life. The difference between emollient A and no moisturiser is more than six months, 15% fewer flare-up cycles, improving greatly patients' quality of life.

These results are similar in the utility analysis. Emollient A is the most effective strategy. Utility under this treatment amounts to 4.19 QALY while emollient B to 4.18 QALY. Unsurprisingly the no moisturiser treatment

Table 2 Cost of Treatment

Emollient	Daily Applications	Quantity/Application	g/Day	g/Cycle	Net Cost £ ^{18,19}	Cost/Cycle £
Emollient A	2	–	–	191.60 ⁹	0.0311	6.27
Emollient B	2	5.35 ¹⁶	10.7	299.6	0.0121	3.81
Emollient C	3	5.6875 ¹⁶	17.0625	477.75	0.1246	62.67
Emollient D	2	5.6875 ¹⁵	11.375	318.5	0.0317	10.63
Corticosteroids	0.71 ²⁰	5.9		118	0.1079	12.74

Table 3 Resources and Value

Health Consumption	Mean/Year	Frequency of Patients	Value	Cost £
Standard hospitalization in patient with mild AD	2	1.80%	Healthcare Resource Group JD07K	423.00
Day hospitalization in patient with mild AD	1	0.40%	Healthcare Resource Group JD07K	423.00
Dermatology related hospital admissions in patients with moderate/severe AD	0.14	100.00%	Healthcare Resource Group JD07K	423.00
Primary care visits in patients with moderate/severe AD	17.72	100% (Flare-up)	GP consultation	38.00
Dermatology clinic outpatient visits in patients with moderate/severe AD	7.53	100% (Flare up)	Dermatology outpatient clinic	56.00
Sick leave in patients with mild AD (days/year)	0.1	100	Median weekly gross earnings	569.00
Sick leave in patients with moderate AD (days/year)	1.1	100	Median weekly gross earnings	569.00
Absenteeism (hours)	2 (h/visits)	100	Median weekly gross earnings	569.00

utility is 4.12 QALY being the treatment affecting the most the patient's quality of life, asserting the necessity of treatment in the case of AD.

Emollients C and D are less effective than emollient A in each comparison.

Costs

Emollient B is the least expensive as shown in (Table 5). The expenses amount to £1802.75 with physician visit

Table 4 Out-of-pocket Expenditures, ECLA Study

Item	Maintenance		Flare-up	
	Inflated Price £	Frequency %	Inflated Price £	Frequency %
Clothes	39.39	2.8	82.30	19.2
Bandages	34.33	5.3	49.69	25.2
Hygiene Products	39.93	33.7	57.73	70.9
Sun Protection	32.52	24.8	35.33	39.1
Food Supplement	43.55	5.3	79.50	20.6
Other Products	26.74	4.6	61.80	19.7

being the main post of expenses (£1147.01). Moisturiser accounts only for £262.18 during the six-year period.

Emollient A is the second cheapest treatment. The expenses amount to £1844.23 for a six-year period. Physician visits are still the main cost of expenses (£1025.32) however; they are lower than the one with emollient B translating to better efficiency of emollient A.

Surprisingly, no emollient is more expensive than the two previous options, needing a hefty £2251.01 over the course of six-years. While the spending on moisturiser is kept to null, need of physician service are skyrocketing to £1774.64. The decrease in moisturiser spending is more than counterbalanced by the increase in physician needs.

The costs of the MD emollient C are much more important (£6337.85). The cost of moisturiser alone (£4410.95) is higher than all other treatments. This is due to the large increase in the emollient cost by mL and the need to use more emollient—one application more a day—to achieve a soothing effect. Cost of physician visits are raised, translating to a lower effectiveness.

Emollient D, while not as expensive as emollient C (£2822.69), is more expensive than emollients A and B. Emollient D needs almost 125 g/cycle more than emollient A to relieve the symptoms in a similar way, and costs almost the same (0.033 vs 0.032 £/mL).

Incremental Cost Effectiveness Ratio

Emollient A is both more expensive and effective than emollient B. The difference in cost amounts to £41.48 and the difference in effectiveness is 0.097 YWFU.

Table 5 Model Results, Effectiveness and Cost Details

	Emollient A	No Moisturiser	Emollient B	Emollient C	Emollient D
EFFICACY					
Number of cycles in flare-up state	10.63	18.41	11.89	15.43	16.94
Number of cycles in maintenance state	59.75	51.98	58.49	54.95	53.45
Time without flare-ups	4.58	3.99	4.49	4.22	4.10
QALY	4.19	4.12	4.18	4.15	4.13
Percent of time in perfect health	70%	69%	70%	69%	69%
COST					
Corticoid	£132.42	£229.26	£148.15	£192.26	£210.99
Hospitalization	£126.20	£151.50	£130.31	£141.83	£146.72
Physician visits	£924.34	£1600.33	£1034.10	£1342.01	£1472.75
Medical Expenses (1)	£1182.95	£1981.09	£1312.55	£1676.09	£1830.45
Moisturiser	£441.37	–	£262.18	£4410.95	£731.76
OOP expenses	£219.90	£269.2	£228.02	£250.81	£260.48
Ancillary Expenses (2)	£661.27	£269.92	£490.21	£4661.76	£992.24
Loss of productivity (3)	£652.57	£1117.62	£728.08	£939.90	£1029.85
Total All Payer Perspective (1+2)	£1844.23	£2251.01	£1802.75	£6337.85	£2822.69
Total Societal Perspective (1+2+3)	£2496.80	£3368.63	£2530.83	£7277.75	£3852.54

Therefore, ICER is £428.30/YWUFU (Table 6). It will cost £428.30 for an additional year without flare-ups.

Emollient A is the dominant strategy compared to no treatment, 217 more days (about two-thirds of a year) without flare-ups and £406.78 cheaper. The other two strategies are dominated as well since they are both more expensive and less effective than emollient A.

The efficiency frontier (Figure 2) is composed only of the two efficient strategies: emollient B and emollient A. Every strategy figuring on the right of the efficiency frontier is considered inefficient. A cost-utility analysis was also implemented. The incremental cost utility ratio (ICUR) between emollient A and emollient B is £3882.97/QALY. The other strategies are dominated.

Sensitivity Analysis

Results of the deterministic sensitivity analysis are showed in Figure 3. The main causes of variability in the results

are the probabilities of transition M_f . Unsurprisingly variation of the cost of products are an important source of variability regarding the cost of treatment. Other probabilities of transition are reasons of variability in the efficiency of the treatment.

For PSA we ran 1000 simulations. While comparing emollient A and no moisturiser, 100% of the simulations show emollient A as more effective. Figure 3A Emollient A is less expensive in 80% of the simulation, therefore the dominant strategy.

Comparing emollients A and B we found emollient A the dominant strategy 45% of the time (Figure 3B). Emollient A is costlier and more effective in 43% of the simulations and is dominated in 9%. This confirms that emollient A is cost effective.

For a willingness to pay (WTP) below £50, a strategy figuring emollient B maximizes the net monetary benefit, with

Table 6 Cost Efficiency Results, Base-case

Emollient	Costs (£)	ΔC (£)	Benefit (YWUFU)	ΔB (YWUFU)	ICER (£/YWUFU)
Emollient B	1802.75		4.487		
Emollient A	1844.23	41.48	4.584	0.097	428.30
No moisturiser	2251.01	406.78	3.987	-0.596	Dominated
Emollient D	2822.69	978.46	4.100	-0.484	Dominated
Emollient C	6337.85	4493.62	4.215	-0.369	Dominated



Figure 2 Efficiency frontier of cost-effectiveness of different strategies in AD treatment.

a probability of 48% (Figure 4). From £200 and upwards emollient A maximizes the net monetary benefit and has the highest probability of being cost-effective. For a WTP of £8000, emollient A has a probability of being cost effective of 81%.

The no moisturiser strategy has a probability of 9% of being cost-effective when the willingness to pay is £0, it rapidly decreases to 2% for a WTP of £500. Strategies using the other two moisturisers are never efficient regardless of the WTP.

In a sensitivity analysis, we modified the time horizon and used a one-year time horizon: emollient A is always the most effective (0.84 YWFU) compared to emollient B (0.82 YWFU) and no moisturiser (0.73 YWFU). Emollient B is still the cheapest strategy (£316.89 against £324.97 for emollient A). In this analysis, the ICER is increased to £471.37/YWFU. No moisturiser is dominated (£397.07).

This perspective was completed by a societal perspective with the loss of productivity accounted for. In this context we found the A emollient to be the cheapest (£2496.80) (Table 5) and the most effective strategy, thus dominating all the other strategies. The better effectiveness of emollient A allowed less visits to the GP resulting in less productivity losses, thus making this strategy dominant.

Discussion

To our knowledge, this study is the first cost-effectiveness analysis of emollients. We tried to bring concepts usually

used within the drugs to skin care products. The National Health Service (NHS) perspective was not adopted as no public insurance is willing to pay for emollients, therefore our option was to choose the health care system and the societal point of view.

The distinctions made in the study allows a good understanding of the different costs in the treatment of AD. The societal perspective is the most thorough and adapted to a study like this one. Indeed, multiple aspects of AD are often silenced. The hidden out-of-pocket costs of AD such as clothes and skin care products (ie cleanser, moisturisers) should necessarily be accounted for. Moreover, the productivity losses due to absenteeism should be accounted for. They reflect the reality of caring parents of children suffering from AD and the difficulties faced by adults suffering from AD in the workplace. Overall data are sparse. Most data come from expert dermatologist's opinions, or from short duration clinical trials.

Therefore, hypotheses made in this study are limited (seldom strong). Nevertheless, hypotheses were thoroughly tested in the sensitivity analysis and the base case scenario conclusions were not called into question.

In order to get closer to the UK market and although methodologically there are some differences between Cetraben cream and Doublebase gel, some of the most commonly used products on this market, when compared to

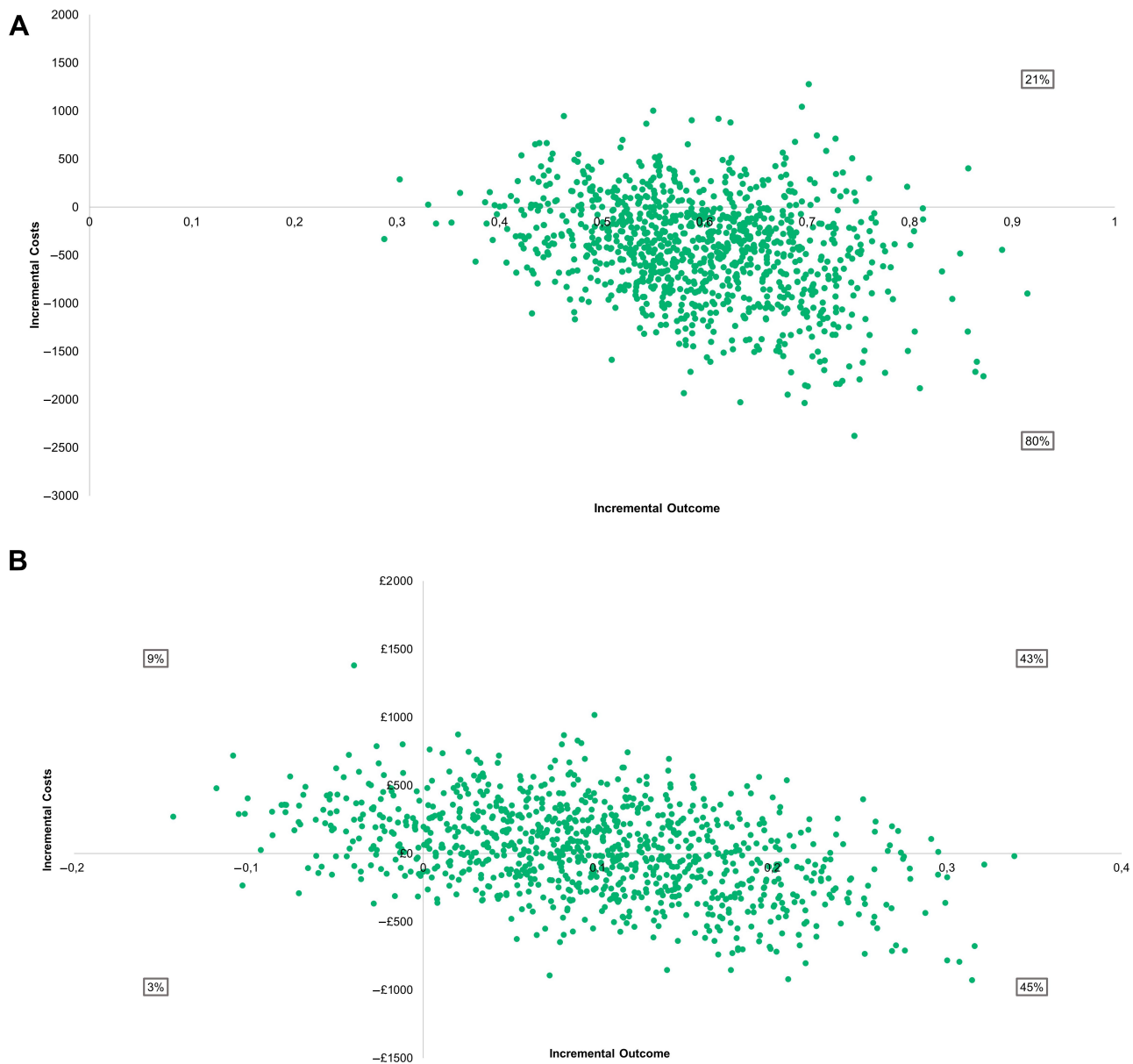


Figure 3 Probabilistic sensitivity analysis. (A) Emollient A vs no moisturizer, (B) Emollient A vs emollient B.

emollient B (not strictly equivalent to the former in their quantitative composition of each ingredient), the ingredients are indeed similar. One of the main active ingredients in these three products is glycerol, hence, with careful interpretation, we still want to remember those comparators relevant to the UK market. As emollient B is not widely distributed (despite being available on the UK market), we have included those two similar available comparators. While the composition is the same qualitatively, quantitatively it may differ and impact the efficacy. High performance liquid chromatography should be used to generalize the results. Nevertheless, we can assume that they will show similar QALY and similar

efficacy with the same quantity/application and daily application as emollient B. In terms of price, price of Doublebase and Cetraben per g were £0.01166 and £0.01198, respectively which is similar to the price for emollient B (£0.0121). We can assume that Cetraben and Doublebase would probably show similar ICER as emollient B if it were to be involved in the study, which again emphasize that emollient A is still more expensive and more efficient.

We also assumed that transition probabilities were the same for Mf and Pf given the lack of data. Experts asserts there is a difference, perhaps a rebound effect. However, this effect is not yet quantified, therefore it was impossible to construct the

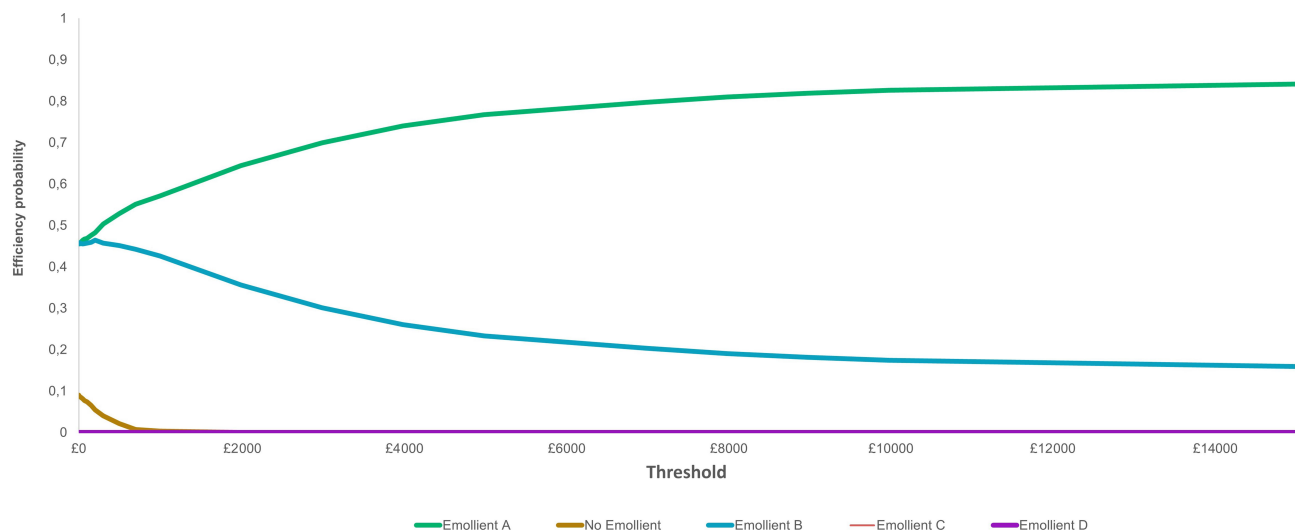


Figure 4 Acceptability curves of different treatment strategy in AD.

model using this assumption. It would be necessary to realize a study where patients are followed for more than four weeks.

Emollients A and B have similar effectiveness. Still emollient A has the edge over emollient B in the base-case scenario and in most probabilistic sensitivity analysis. Overall emollient A is the most effective in relieving AD symptoms in our comparison.

Regarding quality of life, this model does not consider the benefits that most differentiate emollients from their moisturizing capacity. The number of daily applications while they are taken in the price computation are a burden to the quality of life and not accounted for. The cosmetic properties can also be considered. If the emollient does not dry or be absorbed quickly enough it will be more difficult to dress after use. This consideration is not well measured yet and can potentially increase the gap between the different emollients efficacy.

In regards of costs, the main expenditure item is the physicians's consultations. These hidden costs should be accounted for in the prescription of an emollient. The studied emollient is the one with the smaller number of consultations (less cost). While no moisturiser is the less costly option regarding emollients expenditure, the cost for the society is high as most of cost of treatment came from consultations.

Emollient A is more expensive and more efficient. Over a six-year period the £428.30/YWFU ICER shows that while it is costlier than the mass market emollient B it is not that much more expensive.

The no moisturiser option was necessary to investigate. While it is deemed as the less costly treatment by the general population, in the end it is more expensive than emollient A or B. This confirms that the main costs in the AD treatment are not the obvious one, questioning the policy of no

reimbursement of moisturiser from the mandatory health insurance. Even though for a WTP of £0, no moisturiser is not the most probable efficient strategy.

Emollients A and B are composing the efficiency frontier and dominating all the other clinical options. Even given the stated weakness of the model, further investigations should be done to allow better care. Today, given the ever-shrinking health assurance budgets the most efficient treatment should be accounted for.

Disclosure

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