APJAI
Asian Pacific Journal of
Allergy and Immunology

ORIGINAL ARTICLE

Cost-effectiveness analysis of corticosteroid nasal sprays for allergic rhinitis in Japan

Naoto Nakagawa, Masami Kashiwabara, Kei Egawa

Abstract

Background: Inflammation of the nasal lining, resulting in rhinorrhea and sneezing, leads to productivity losses.

Objective: We aimed to clarify which corticosteroid nasal spray, dexamethasone cipecilate, fluticasone furoate, fluticasone propionate, or mometasone furoate hydrate, is more cost-effective in treating allergic rhinitis in Japan from the perspective of healthcare payers.

Methods: A decision tree was generated using data on transition probabilities of effectiveness and side effects retrieved from post-marketing surveillance data. Direct medical costs were sourced from Medical Fee Index 2022. The drug prices were determined using the Drug Price Index 2021. Utilities were determined using the EQ-5D-5L scale. Deterministic and probabilistic sensitivity analyses were conducted to examine the robustness of the results. Prescription data for the fiscal year 2020 were also examined.

Results: The incremental cost of mometasone furoate hydrate, dexamethasone cipecilate, and fluticasone furoate compared with that of fluticasone propionate was 200 JPY (1.99 USD), 440 JPY (4.37 USD), and 760 JPY (7.54 USD), respectively. The incremental effectiveness of mometasone furoate hydrate, dexamethasone cipecilate, and fluticasone furoate compared with that of fluticasone propionate was -0.0004, -0.0004, and -0.0002, respectively. Thus, mometasone furoate hydrate, dexamethasone cipecilate, and fluticasone furoate were dominated by fluticasone propionate. The sensitivity analyses showed that the result was robust. Prescription data showed that fluticasone furoate was prescribed most often, followed by mometasone furoate hydrate.

Conclusion: Fluticasone propionate is the most cost-effective agent. As it was not often prescribed in the fiscal year 2020, physicians should understand our results to sustain the reduction of healthcare expenditures.

Key words: nasal spray, dexamethasone cipecilate, fluticasone furoate, fluticasone propionate, mometasone furoate hydrate, allergic rhinitis

Citation:
Nakagawa, N., Kashiwabara, M., Egawa, K. (0000). Cost-effectiveness analysis of corticosteroid nasal sprays for allergic rhinitis in Japan. *Asian Pac J Allergy Immunol*, 00(0), 000-000. https://doi.org/10.12932/ap-250625-2105

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Introduction

Allergic rhinitis is caused by a type 1 hypersensitivity reaction occurring within the nasal mucosa in response to aeroallergens. The reaction occurs when aeroallergens interact with immunoglobulin E antibodies on cells in the nasal mucosa; inflammation follows the symptoms of rhinorrhea, congestion, and sneezing.[1] The affected adult population has been estimated to be 12%–30% in the United States of America, 26% in the United Kingdom, and 23%–30% in European countries.[1] The allergic rhinitis incidence has substantially increased over the last four decades. In recent years, productivity losses have raised concerns regarding societal issues. The pharmacoeconomic effect of allergic rhinitis has also become a concern. Thus, discussions on the cost-effectiveness of allergic rhinitis treatment are crucial.

Atopic dermatitis and asthma are associated with allergic rhinitis.[2,3] Allergic rhinitis treatments should be evaluated clinically and economically. The mainstay treatments for allergic rhinitis include oral antihistamine inhibitors and corticosteroid nasal sprays. Oral antihistamines have been the subject of many cost-effectiveness analyses, but most of these studies are outdated.[4,5] Reportedly, ebastine is the most cost-effective second-generation antihistamine in Japan.[6] Japanese studies on corticosteroid nasal sprays are limited.[7]

A formulary system has gradually been introduced in the Japanese healthcare system;[8] however, it does not appear to be designed from a pharmacoeconomic perspective. Pharmacoeconomic evidence on allergic rhinitis treatments differs between Japan and Western countries. While studies on antihistamines and intranasal corticosteroids are prevalent in Western literature,[9] few cost-effectiveness analysis of intranasal corticosteroids has been conducted in Japan.[6] This gap hinders the development of an evidence-based formulary for allergic rhinitis in Japan. The 2017 therapeutic guidelines for allergic rhinitis highlighted the role of intranasal steroids in the pharmacotherapy section;[10] however, the guidelines did not include a section addressing the cost-effectiveness.

The Japanese healthcare system provides universal coverage through a multi-tiered public insurance framework and regulates fee-for-service payments, enabling direct access to specialists and delivering superior health outcomes at moderate costs (~$4,400 per capita).[11] However, healthcare systems in European countries predominantly operate through tax-funded or social insurance frameworks.[11] Hence, cost-effectiveness analyses should be conducted in Japan to develop precise formularies.

In Japan, fluticasone propionate (FP) and mometasone furoate hydrate (MFH) are already available. As comparative agents such as budesonide and beclomethasone dipropionate nasal sprays are not approved in Japan, it is difficult to determine the clinical and economic effects of corticosteroids. Additionally, most pharmacoeconomic studies have been conducted in Western countries; therefore, it is difficult to apply the results to Japanese healthcare system. To analyze cost-effectiveness in Japan, original data are preferred. Japan markets four corticosteroid nasal sprays, dexamethasone cipecilate (DC), fluticasone furoate (FF), FP, and MFH. Post-marketing surveillance of these agents has already been conducted, and using Japanese data is ideal to evaluate allergic rhinitis treatment with corticosteroid nasal sprays. The aim of this study was to determine which corticosteroid nasal spray is most cost-effective in Japan.

Methods

Study design

This study was conducted under a base–case scenario. The target population was adults aged over 18 years with allergic rhinitis in outpatient settings in Japan. As allergic rhinitis is a common disorder in Japan and many patients visit physicians for allergic rhinitis medication prescriptions, which may have an effect on Japan's healthcare cost, the study was performed from the perspective of healthcare payers. The time horizon was set as 14 days because the volume of medicine contained in bottle of common corticosteroid intranasal sprays can last 14 days. Additionally, most randomized clinical trials on seasonal allergic rhinitis or perennial allergic rhinitis have employed a 2-week administration period to assess the efficacy and safety of intranasal corticosteroid sprays.[12,13] Therefore, our study set the time horizon as 14 days. As FP is the oldest available corticosteroid nasal spray, marketed since 1994 in Japan, it was used as a comparator in this study. Additionally, the number of corticosteroid nasal sprays prescribed in the fiscal year 2020 was investigated to verify whether the current prescription trends are suitable from a pharmacoeconomic perspective.

Decision tree

Figure 1 shows the decision tree for the cost-effectiveness analysis. Data on the transition probabilities for effectiveness and side effects were retrieved from post-marketing surveillance data for each agent from the Pharmaceuticals and Medical Devices Agency (PMDA) website (https://www.pmda.go.jp/english/). The transition probability of the effectiveness of DC, FF, FP, and MFH was 88.0%,[14] 92.7%,[15] 96.5%,[16] and 88.1%,[17] respectively. The probability of side effects for DC, FF, FP, and MFH was 1.2%,[14] 0.6%,[15] 0.7%,[16] and 1.5%,[17] respectively. The definitions of each disease state are as follows: disease state 1: corticosteroid nasal spray was effective, but side effects occurred; disease state 2: corticosteroid nasal spray was effective and side effects did not occur; disease state 3: corticosteroid nasal spray was ineffective and side effects occurred; and disease state 4: corticosteroid nasal spray was ineffective and side effects did not occur.

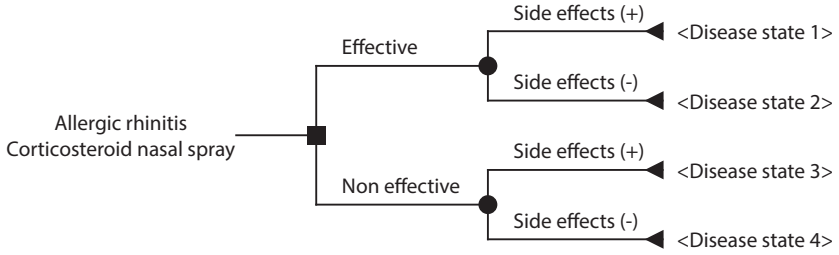


Figure 1. Decision tree.

Calculating direct costs

Direct medical costs were identified as payable costs for outpatient clinics and community pharmacies. The former contained a charge for an initial medical examination, rhinoscopy, nasal procedure (nebulization), prescription, and prescription delivery. The latter contained a charge for basic dispensing of class 2 pharmacy, drug preparation for external use medication, and medication administration and instruction fee. These charges were retrieved from Medical Fee Index 2022 (see **Table S1**).[18]

Drug prices for corticosteroid intranasal sprays were sourced from Drug Price Index 2021,[19] because it was not updated in 2022. As the volume of medicine contained in bottle of common corticosteroid intranasal sprays can last 14 days, drug prices were applied as one bottle of spray for a 14-day treatment. JPY was converted to USD with the value of USD at purchasing power parity (PPP) using the Organization for Economic Co-operation and Development conversion factors (1 USD = 100.742085 yen).[20] PPP is widely recognized as an effective long-term tool for assessing price convergence[21] and is acknowledged for its utility in long-term forex trading strategies,[22] supporting its suitability for long-term evaluation. Furthermore, recent pharmacoeconomic studies have predominantly adopted PPP.[23,24] Consequently, PPP is favored over the market exchange rate.

Estimation of utilities

Outcome measurements were identified using non-identified EuroQol 5 dimensions 5-level (EQ-5D-5L) questionnaires administered to patients with allergic rhinitis who visited a pharmacy to receive corticosteroid nasal sprays. Pharmacists explained the purpose of the questionnaire with a letter, and patients provided informed consent to participate in the study. Patients with actual disease states occasionally imagined disease states compared to their actual conditions. However, this study did not assess patient adherence or include skin prick tests to identify allergens. Data from the questionnaire were converted into utilities using the Japanese tariff. Quality-adjusted life-years (QALYs) were computed using the following formula:

$$\text{QALY} = \text{utilities} \times 14 / 365.$$

Sensitivity analyses

A one-way sensitivity analysis was conducted based on cost-effectiveness analysis using deterministic sensitivity analysis (DSA). A two-way sensitivity analysis was performed when two parameters were sensitive to the results. Although tornado diagrams with incremental cost-effectiveness ratio (ICER) are commonly used for visualizing the analysis results, we have shown the results with incremental net monetary benefits (INMB) because there were infinity signs in the tornado diagrams with ICERs. Therefore, the incremental effectiveness passed through zero, making the ICER calculation undefined. Willingness to pay (WTP) for Japan was defined as 5,000,000 JPY/QALY (49,632 USD/QALY).[25]

To further examine this uncertainty, probabilistic sensitivity analysis (PSA) was performed. The transition probabilities and QALYs were adopted as beta distributions. The costs were the gamma distributions adopted. A Monte Carlo simulation with 10,000 iterations was used to examine the uncertainty in utility, probability, and cost inputs using TreeAge Pro Healthcare version 2025 (TreeAge Software, LLC., Williamstown, MA, USA). The input data are presented in **Table 1**.

Table 1. Clinical, utility, and cost inputs and ranges used in the sensitivity analyses.

Parameter	Base case value	Lower limit	Higher limit	Distribution	Distribution parameter (α/β : μ/σ)	Reference
Cost of pharmacy	990	891	1,089	Gamma (μ : σ)	990 : 99	18
Cost of physician	6,000	5,400	6,600	Gamma (μ : σ)	6,000 : 600	18
Price of DC	1,350	1,485	1,512	Gamma (μ : σ)	1,350 : 135	19
Price of FF	1,670	342.2	1,837	Gamma (μ : σ)	1,670 : 167	19
Price of FP	910	342.2	1,001	Gamma (μ : σ)	910 : 91	19
Price of MFH	1,110	475.1	1,221	Gamma (μ : σ)	1,110 : 111	19
Effective probability of DC	0.88	0.792	0.968	Beta (α : β)	2487 : 339	14
Effective probability of FF	0.927	0.8343	1	Beta (α : β)	1344 : 106	15
Effective probability of FP	0.965	0.8685	1	Beta (α : β)	3031 : 110	16
Effective probability of MFH	0.881	0.7929	0.9691	Beta (α : β)	2124 : 287	17
Side effect probability of DC	0.012	0.0108	0.0132	Beta (α : β)	35 : 2917	14
Side effect probability of FF	0.006	0.0054	0.0066	Beta (α : β)	10 : 1574	15
Side effect probability of FP	0.007	0.0063	0.022	Beta (α : β)	22 : 3186	16
Side effect probability of MFH	0.015	0.0135	0.0165	Beta (α : β)	43 : 2837	17

Table 1. (Continued)

Parameter	Base case value	Lower limit	Higher limit	Distribution	Distribution parameter (α/β : μ/σ)	Reference
Utility of disease state 1	0.0331	0.0315	0.0347	Beta (μ : σ)	0.0331 : 0.0045	-
Utility of disease state 2	0.0380	0.0376	0.0384	Beta (μ : σ)	0.0380 : 0.0012	-
Utility of disease state 3	0.0314	0.029	0.0339	Beta (μ : σ)	0.0314 : 0.0069	-
Utility of disease state 4	0.0334	0.0306	0.0363	Beta (μ : σ)	0.0334 : 0.0081	-

Abbreviations: DC, dexamethasone cipecilate; FF, fluticasone furoate; FP, fluticasone propionate; MFH, mometasone furoate hydrate; QALY, quality-adjusted life years

National database for the prescription of corticosteroid nasal sprays

The national database for the external use of medication for 2020, which contained the most recent data, was accessed on the Ministry of Health, Labour and Welfare's website.[26] Prescription data were retrieved to investigate whether the prescription data for corticosteroid nasal sprays are valid in relation to the results of this study.

Ethical committee approval

Ethical approval for this study (Ethical Committee Number 282) was provided by the Ethical Committee of Ohu University, Fukushima, Japan (Chairperson Prof Y. Kiyoura) on December 11, 2019.

Consent to participate

The letter for informed consent described the purpose of the study, indicated that patients' identifiable information would never be made public and that no disadvantage would suffer if the patients did not cooperate with the study, and specified the retention period of the questionnaires. Informed consent was obtained in February and March 2020 at a community pharmacy during Japan's cedar pollen season. EQ-5D-5L questionnaires were distributed promptly to support the study. The study's representativeness is limited, as only one outpatient clinic, one pharmacy, and one physician participated, ensuring consistent diagnostic criteria and minimal bias.

Results

This study involved 34 patients. The utility for disease states 1, 2, 3, and 4 was 0.863 (95% confidential interval (CI): 0.822–0.904), 0.991 (95% CI: 0.980–1.001), 0.820 (95% CI: 0.757–0.883), and 0.871 (95% CI: 0.797–0.944), respectively. The corresponding QALY was 0.0331 (95% CI: 0.0315–0.0347), 0.0380 (95% CI: 0.0376–0.0384), 0.0314 (95% CI: 0.0290–0.0339), and 0.0334 (95% CI: 0.0306–0.0362), respectively. In the base–case scenario, each branch had side effects, and the utilities with side effects were lower than those with no side effects, which was reasonable.

Table 2 shows the results of the cost-effectiveness analyses. The cost of FP, MFH, DC, and FF was 7,900, 8,100, 8,340, and 8,660 JPY (78.42, 80.40, 82.79, and 85.96 USD), respectively. The incremental cost of MFH, DC, and FF compared with that of FP was 200, 440, and 760 JPY (1.99, 4.37, and 7.54 USD), respectively. The effectiveness of FP, MFH, DC, and FF was 0.03781, 0.03738, 0.03739, and 0.03763 QALY, respectively. The incremental effectiveness of MFH, DC, and FF compared with that of FP was -0.0004, -0.0004, and -0.0002, respectively. Consequently, MFH, DC, and FF were dominated by FP.

Figure 2 presents the outcomes of the deterministic sensitivity analysis comparing DC, FF, and MFH with FP. In **Figure 2(A)**, the expected value (EV) for DC was calculated as -2,499 JPY (-24.81 USD). At this point, FP demonstrated superior cost-effectiveness compared to DC. The negative EV values remained unchanged across all parameters,

Table 2 Cost effectiveness analysis.

Strategy	Cost (JPY)	Increased Cost (JPY)	Effectiveness (QALY)	Increased Effectiveness (QALY)	ICER (JPY/QALY)	NMB (JPY)	INMB (JPY)
Fluticasone propionate (FP)	7,900 (78.42 USD)	-	0.03781	-	-	181,130 (1,798 USD)	Reference
Mometasone furoate hydrate (MFH)	8,100 (80.40 USD)	200 (1.99 USD)	0.03738	-0.0004	Dominated	178,822 (1,775 USD)	-2,308 (-22.91 USD)
Dexamethasone cipecilate (DC)	8,340 (82.79 USD)	440 (4.37 USD)	0.03739	-0.0004	Dominated	178,631 (1,773 USD)	-2,499 (-24.81 USD)
Fluticasone furoate (FF)	8,660 (85.96 USD)	760 (7.54 USD)	0.03763	-0.0002	Dominated	179,511 (1,782 USD)	-1,619 (-16.07 USD)

Abbreviations: QALY, quality-adjusted life year; ICER, incremental cost effectiveness ratio; NMB, net monetary benefit.

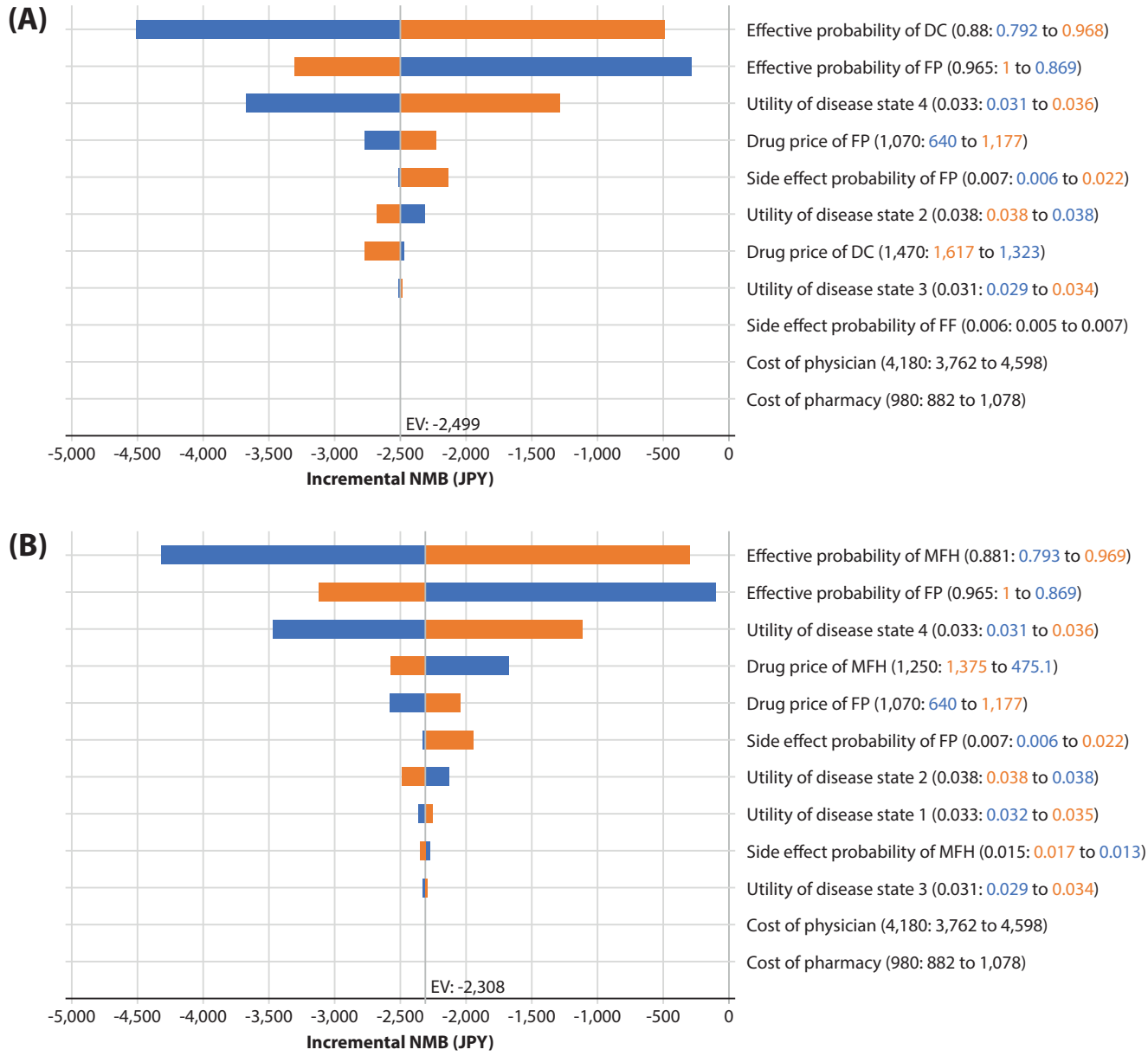
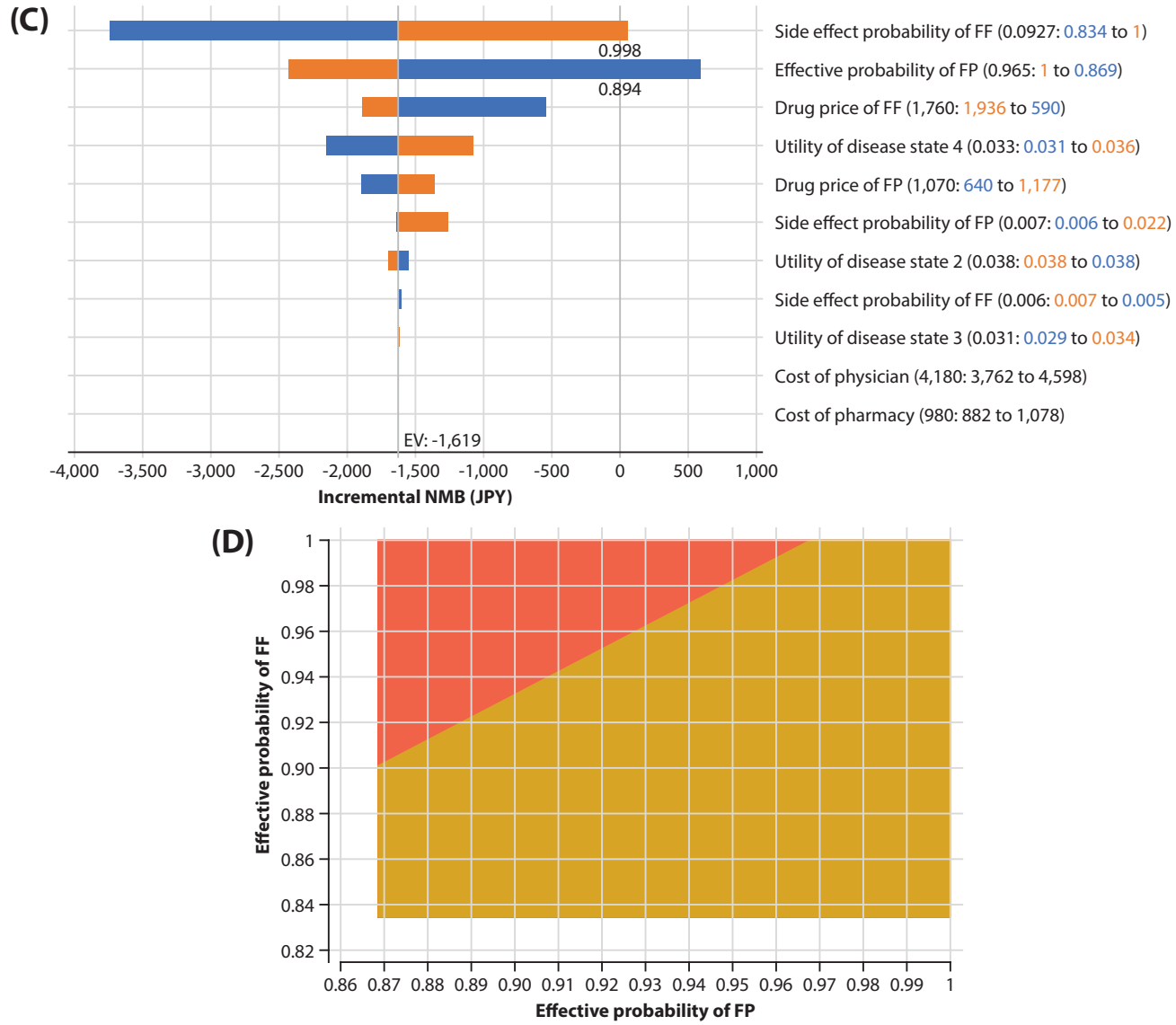


Figure 2. Deterministic sensitivity analysis. (A) One-way sensitivity analysis of dexamethasone cipecilate compared to fluticasone propionate, (B) one-way sensitivity analysis of mometasone furoate hydrate compared to fluticasone propionate, (C) one-way sensitivity analysis of fluticasone furoate compared to fluticasone propionate, and (D) two-way sensitivity analysis of the effective probability of fluticasone furoate and fluticasone propionate. Yellow and red present FP and FF, respectively.

DC: Dexamethasone cipecilate, FF: fluticasone furoate, FP: fluticasone propionate, MFH: mometasone furoate hydrate, NMB: net monetary benefit.



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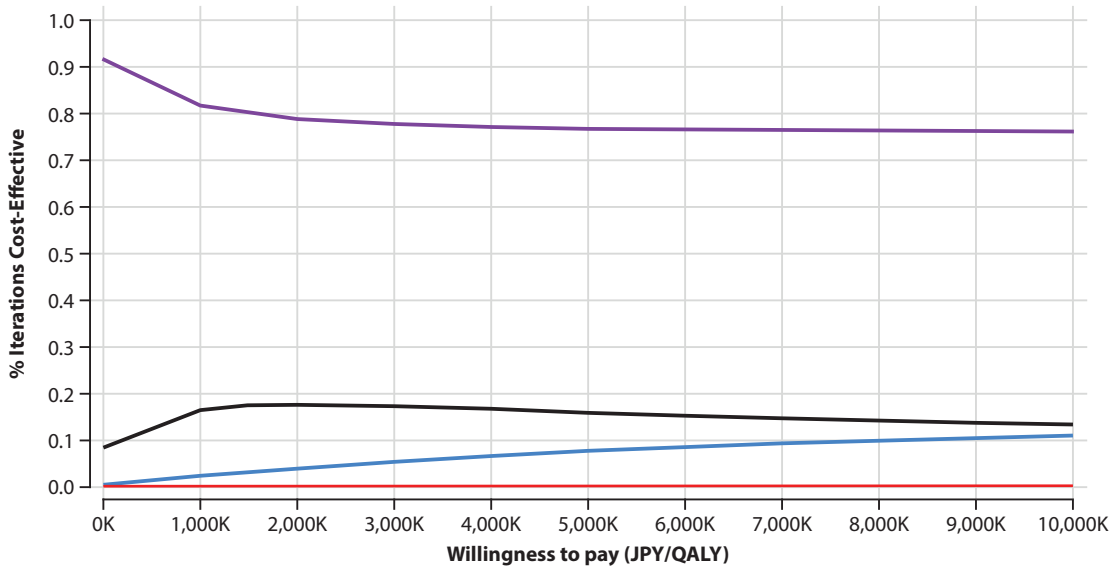

Figure 3. Probabilistic sensitivity analysis. Acceptability curve.
Dexamethasone cipecilate, fluticasone furoate, fluticasone propionate, and mometasone furoate hydrate are represented in blue, red, purple, and black, respectively.
QALY: quality-adjusted life years, K: 1,000

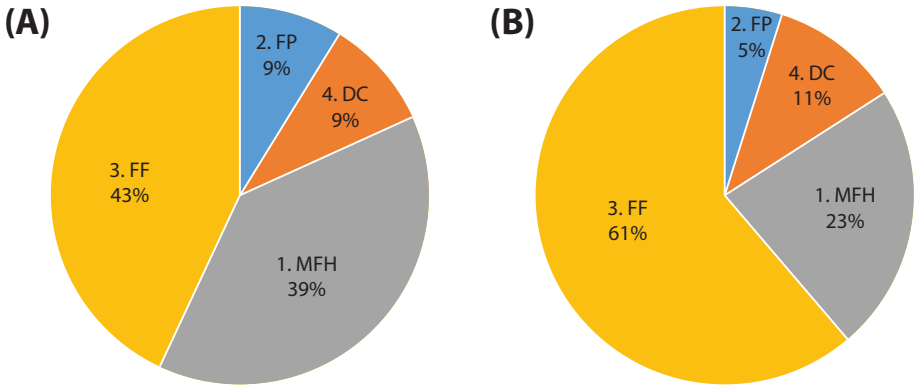

Figure 4. Prescription data for steroid nasal sprays in 2020. (A) Prescription data. (B) Drug costs. (As of the fiscal year 2020, generic medications for FF and DC are not available in Japan)

DC: Dexamethasone cipecilate, FF: fluticasone furoate, FP: fluticasone propionate, MFH: mometasone furoate hydrate,

indicating the robustness of FP dominance. Similarly, in **Figure 2(B)**, the EV for MFH was -2,308 JPY (-22.91 USD), with FP again exhibiting greater cost-effectiveness. The negative EV values did not transition to positive values for any parameter, reaffirming the robustness of the superiority of FP. In **Figure 2(C)**, the EV for FF was -1,619 JPY (-16.07 USD). While FP remained superior in terms of cost-effectiveness, the negative EV values shifted to positive values for the parameters "effective probability of FF" and "effective probability of FP," suggesting that the dominance of FP was not robust in this case. Consequently, a two-way sensitivity analysis of the effective probabilities of FF and FP was conducted, with results presented in **Figure 2(D)**. The analysis revealed that the area representing FP was larger than that of FF, indicating that FP is more cost-effective than FF.

Figure 3 shows the acceptability curve from the WTP of 0 JPY/QALY to 10,000,000 JPY/QALY (99,263 USD/QALY) based on the PSA. The acceptable dominance of FP gradually decreased with increasing WTP; however, it plateaued at 1,000,000 JPY/QALY (99,263 USD/QALY), suggesting that the dominance of FP was rigid.

Figure 4(A) shows the prescription data for corticosteroid nasal sprays based on the number of bottles prescribed in the fiscal year 2020. The prescription rate of FF was 43% (7,273,600/16,907,990 bottles), making FF the most prescribed. MFH was prescribed for 39% of the patients (6,558,590/16,907,990 bottles). However, the prescription percentages of FP and DC were low (9%, 1,492,660/16,907,990 bottles for FP; 9%, 1,583,139/16,907,990 bottles for DC). **Figure 4(B)** shows the prescription data based on drug costs in the fiscal year 2020. Similar to the above results, FF was the most expensive corticosteroid nasal spray (61%; 12,810,992,244/20,936,957,196 JPY, approximately 127 million/208 million USD), followed by MFH at 23% (JPY 4,781,792,882/20,936,957,196; approximately USD 47 million/208 million). However, FP and DC had a low prescription percentage: 5% for FP (1,022,499,313/20,936,957,196 JPY, 10 million/208 million USD) and 11% for DC (2,321,672,757/20,936,957,196 JPY, 23 million/208 million USD). Therefore, the most cost-effective agent, FP, was not often prescribed in Japan.

Table S2, shows the marketed year for the four corticosteroid nasal sprays in Japan. FP has been marked since 1994, and the other agents have been marketed since the 2000s. Prescriptions for FP, even generic brands, were relatively fewer.

Discussion

Here, we found that FP is a cost-effective agent for allergic rhinitis management. As FF and MFH were as less cost-effective as corticosteroid nasal sprays but were often prescribed, physicians could use the results of this study to sustain and reduce healthcare expenditures. Pharmacoeconomic studies in Japan have gradually increased in number. Nonetheless, there are only a few applications of such research recommendations in daily clinical practice. Therefore, pharmacoeconomic study results are expected to be applied to clinical practices more efficiently to create a new formulary in hospital and community settings.

FP is not frequently prescribed in Japan for allergic rhinitis treatment. Considering the data presented in **Table S2** and **Figure 4**, which indicate that FF and MFH were prescribed frequently, most physicians may prescribe newly approved agents. A Japanese group reported the prescription trends of proton pump inhibitors (PPIs) in Japan.[27] In 2010, prescriptions for older PPIs like omeprazole were low, while newer options such as lansoprazole and rabeprazole were preferred. Vonoprazan, introduced in 2015, saw rapid adoption by 2016, reflecting physicians' tendency to favor newer agents.[27] Similarly, newer corticosteroid nasal sprays are often prescribed over FP for allergic rhinitis. DC is the most recently marketed corticosteroid nasal spray; however, its prescription has been limited. This may be attributed to restricted promotional efforts by the pharmaceutical company. Furthermore, the efficacy of DC was found to be lower than that of FF, FP, and MFH (**Table 1**), which may lead physicians to avoid prescribing DC in clinical practice.

Some economic evaluations regarding corticosteroid nasal sprays have been reported.[7,28-30] FF reportedly resulted in lower costs per patient, potentially leading to substantial savings in healthcare plans.[28] MFH use for treating pediatric patients with allergic rhinitis is a predominant strategy.[7]

Treatment with MFH 200 μg twice daily results in reduced costs and improved health-related QOL in patients with acute rhinosinusitis compared to amoxicillin treatment or self-medication.[29] Budesonide aqueous nasal spray has been reported to be more cost-effective than FP nasal spray in perennial allergic rhinitis treatment, and the result was driven by the difference in drug costs in Canada.[30] A cost-effectiveness analysis conducted in the Thai context indicated that FF was the most cost-effective option compared to budesonide, MFH, and triamcinolone;[31] FP is not available in the Thai market. As head-to-head economic evaluations among four corticosteroid nasal sprays have not been reported, dominance of FP is still unclear based on the above literature. According to the above studies, FF and MFH seem to be cost-effective for treating allergic rhinitis globally. Although there was a non-inferior trial on DC compared to FP in Japan,[32] economic evaluations of DC have not yet been reported. Here, the drug price of DC (1,350 JPY, 13.40 USD) was higher than that of FP (910 JPY, 9.03 USD). However, the effectiveness of DC was lower than that of FP based on post-marketing surveillance, and this resulted in DC being dominated by FP.

Here, the probability of side effects for DC, FF, FP, and MFH was 1.2%,[14] 0.6%,[15] 0.7%,[16] and 1.5%,[17] respectively. According to the referred studies, there were no serious side effects, and the frequency of side effects was low, thus steroid nasal sprays are safe for allergic rhinitis treatment. Of the four steroid sprays, FP is the most cost-effective agent, with fewer side effects.

The study has some limitations. First, the EQ-5D-5L survey was limited to 34 patients. During the cedar pollen season in Japan, many patients with allergic rhinitis visit pharmacies. Therefore, the pharmacist filling prescriptions may not have been able to obtain informed consent from patients with allergic rhinitis. In order to increase the amount of data, a future survey should involve multiple pharmacies. However, a previous study conducted a similar survey with a relatively small cohort of 23 participants,[33] and therefore, the present study findings cannot be considered unreliable. In addition, the relatively small cohort included in the EQ-5D-5L questionnaire survey may result in wider confidence intervals for utility parameters, thereby increasing the uncertainty in probability distributions utilized in the PSA. The utility parameter with the widest confidence interval was "disease state 4." The DSAs presented in **Figure 2** clearly demonstrate the heightened sensitivity of "utility of disease state 4," which underscores the increased uncertainty. We acknowledge and concur these findings. Importantly, the utilities did not cross the zero bar, suggesting that, despite the small cohort size, the results for FP remained robust. The decision tree was simple, validated through sensitivity analysis. Analytical models are increasingly practical, allowing cost-effectiveness assessments of combination therapies. Evidence from the 2023 consensus on allergic rhinitis indicates no additional benefit of combining oral antihistamines with intranasal corticosteroids over intranasal corticosteroids alone,[34] warranting further economic evaluation. Larger cohorts and longer time frames are needed to better support physicians' prescribing decisions. Nonetheless, this study, the first global comparative evaluation of these four agents, addresses the lack of prior cost-effectiveness analyses.

Conclusion

The results showed that FP was the most cost-effective agent. As FF and MFH were less cost-effective and because they were often prescribed in the fiscal year 2020, physicians should use the results of the study to sustain and reduce healthcare expenditure. This viewpoint is valuable, because more economical and practical strategies for treating allergic rhinitis can be developed.

Acknowledgments

We would like to thank Editage (www.editage.jp) for English language editing.

Conflict of interest

None.

Source of funding with grant numbers

None.

Author contributions

- Conceptualization: Naoto Nakagawa and Kei Egawa
- Methodology: Naoto Nakagawa and Kei Egawa
- Data curation: Masami Kashiwabara
- Formal analysis and investigation: Naoto Nakagawa and Kei Egawa
- Writing - original draft preparation: Naoto Nakagawa
- Writing - review and editing: Masami Kashiwabara and Kei Egawa

Data availability

The datasets used in this study are available at Dryad, Dataset, DOI: 10.5061/dryad.k6djh9wft.

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Supplemental

Table S1. Break-down of costs.

Parameter	Content	Cost (JPY)	Total
Cost of physician	Charge for an initial medical examination	2,880 (28.59 USD)	4,180 (41.49 USD)
	Rhinoscopy	160 (1.59 USD)	
	Nasal procedure (nebulization)	120 (1.19 USD)	
	Prescription	420 (4.17 USD)	
	prescription-delivery fee	600 (5.96 USD)	
Cost of pharmacy	Charge for basic dispensing of class 2 pharmacy	290 (2.88 USD)	980 (9.73 USD)
	Drug preparation for external use medication	100 (0.99 USD)	
	Medication administration and instruction fee	590 (5.86 USD)	

Table S2. Marketed years for corticosteroid nasal sprays.

Corticosteroid nasal spray	Marketed year	Generic available as of 2020
Fluticasone propionate (FP)	1994	Yes
Mometasone furoate hydrate (MFH)	2008	Yes
Fluticasone furoate (FF)	2009	No
Dexamethasone cipecilate (DC)	2012	No