Cost-effectiveness of Fufang Huangbai fluid versus Suprasorb® A + Ag antimicrobial calcium alginate wound dressing for treating IWGDF/IDSA grade 1–2 diabetic foot ulcers

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ABSTRACT

Introduction Diabetic foot infections impose a substantial economic burden globally, particularly in developing countries such as China. This study evaluated the cost-effectiveness of Fufang Huangbai fluid (FHF) compared with Suprasorb® A + Ag antimicrobial calcium alginate wound dressing (SAAAD) for treating grade 1–2 diabetic foot ulcers (DFUs) (graded according to the International Working Group on the Diabetic Foot/the Infectious Diseases Society of America [IWGDF/IDSA]). **Methods** A cost-effectiveness analysis was conducted using 2 weeks of randomized controlled trial data (n = 176) using Chinese healthcare system costs and service fees. Quality-adjusted life years (QALYs) served as the primary health outcome, and costs included drug expenses and dressing services. Both deterministic and probabilistic sensitivity analyses were performed. **Results** Compared with the SAAAD group, the FHF group saved CNY 300.64 and gained an incremental 0.0013 QALYs, making it a dominant approach with a net monetary benefit of CNY 325.86. Sensitivity analysis indicated that the unit price of SAAAD had the greatest impact on the results. At a willingness-to-pay threshold of CNY 20 000 per QALY, the probability of FHF being cost-effective was 70.65%. **Conclusion** FHF is economically advantageous compared with SAAAD for the treatment of DFUs of IWGDF/IDSA grade 1–2.

KEYWORDS

Fufang Huangbai fluid, diabetic foot ulcer, diabetic foot infection, cost-effectiveness analysis, economics, wound dressing

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1. Introduction

Diabetic foot ulcers (DFUs), severe complications of diabetes, are characterized by chronic wounds of the foot resulting from peripheral neuropathy, vascular pathology, and localized inflammation induced by prolonged hyperglycemia. DFUs are difficult to heal and are prone to secondary infections, which can progress to lower-extremity amputation or even mortality, substantially impairing patients' quality of life and long-term prognosis.[1–3]

The global prevalence of diabetes is increasing at an annual rate of 3.31%. By 2021, approximately 530 million people had diabetes, and this number is projected to rise to 1.31 billion by 2050.[4] China has the highest number of patients with diabetes worldwide, with recent studies estimating 233 million individuals with diabetes by 2023, corresponding to an age-standardized prevalence of 13.7%, nearly double that in 2005. If the current trend persists, the prevalence of diabetes in China is projected to reach 29.1% by 2050.[5] Approximately 20%–34% of patients with diabetes may develop DFUs, of whom 60% may experience diabetic foot infection (DFI).[6] Global diabetes-related healthcare expenditures were estimated at $966 billion in 2021 and are projected to reach $1054 billion by 2045.[7] According to the International Diabetes Federation's 2021 Global Diabetes Atlas,[8] developing countries are experiencing the fastest-growing diabetes epidemic, with the disease accounting for up to 40% of healthcare resources.[9] The total economic burden of diabetes in China is projected to reach CNY 460 billion by 2030.[5] Notably, expenditures related to DFUs account for 33% of the total diabetes-related healthcare spending.[2,10] Collectively, the expanding population of patients with DFUs and DFIs will generate significant healthcare demands and impose a substantial economic burden on society and patients.

According to the 2023 guidelines on the diagnosis and treatment of foot infections in patients with diabetes, jointly published by the International Working Group on the Diabetic Foot (IWGDF) and the Infectious Diseases Society of America (IDSA),[11] DFIs are classified into four grades: no infection, mild, moderate, and severe. Patients with grade 1–2 infections represent a high proportion of cases, exhibiting mild symptoms without bone marrow or systemic involvement, and are primarily treated with local antibacterial agents such as silver-ion-containing dressings, betadine ointments, and povidone-iodine solutions. Antimicrobial therapy is guided by bacterial culture and drug-sensitivity testing, and antibiotics are commonly administered as indicated. However, increasing bacterial resistance has created an urgent need to identify new antimicrobial therapies for DFIs.

Wound dressings play a critical role in regulating the local wound microenvironment.[12] They maintain a moist wound environment and control exudates, thereby promoting keratinocyte and fibroblast proliferation and accelerating wound healing. Fufang Huangbai fluid (FHF), composed of five Chinese herbs—*Phellodendron chinense* Schneid. (*P. chinense*, Huang Bo), *Forsythia suspense* (Thunb.) Vahl (*F. suspense*, Lian Qiao), *Lonicera japonica* Thunb. (*L. japonica*, Jin Yin Hua), *Taraxacum mongolicum* Hand.-Mazz. (*T. mongolicum*, Pu Gong Ying), and *Scolopendra subspinipes mutilans* L. Koch (*S. subspinipes*, Wu Gong)—exerts anti-Gram-positive effects, promotes wound healing, and improves non-specific immunity. It is widely used for the treatment of ulcers and wounds, and pharmacological studies indicate that these herbs exhibit synergistic antibacterial effects. Berberine from *P. chinensis* demonstrates potent inhibitory activity against certain drug-resistant bacteria, surpassing that of some conventional antibiotics.[13,14] Forsythiaside from

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F. suspense exhibits significant inhibitory activity against both *Staphylococcus aureus* and *Escherichia coli*.[15] Chlorogenic acid and luteolin from *L. Japonica* show broad-spectrum antimicrobial properties.[16] Taraxasterol and phytic acid from *T. mongolicum* inhibit *Staphylococcus aureus* and *Salmonella*,[17] antimicrobial peptides from *S. subspinipes* demonstrate broad-spectrum antibacterial efficacy.[18]

Clinical trials have confirmed that FHF is effective in treating DFIs and can improve ulcer healing.[19-22] In modern wound care, Suprasorb® A + Ag antimicrobial calcium alginate wound dressings (SAAAD) represent a widely used approach for managing chronically infected wounds. The alginate component of these dressings demonstrates exceptional exudate-absorption capacity, and their efficacy in promoting the healing of DFUs has been extensively validated.[12,23,24] Calcium ions accelerate wound coagulation and effectively control bleeding, while positively charged silver ions inhibit bacterial adhesion and disrupt cell membrane structures, exhibiting inhibitory effects against both Gram-positive and Gram-negative bacteria.[25]

Although SAAAD is expensive, FHF represents a promising and cost-effective alternative for treating DFIs. However, few studies have analyzed the cost-effectiveness of FHF compared with SAAAD, which limits its broader clinical adoption.

This study, based on a randomized controlled trial, aimed to evaluate the cost-effectiveness of FHF as a potential alternative treatment for IWGDF/IDSA grade 1–2 DFUs. The findings provide decision-makers with robust economic evidence to optimize healthcare resource allocation.

2. Methods

2.1. Ethical approval

This study is approved by the Ethics Committee of Dongzhimen Hospital Affiliated to Beijing University of Chinese Medicine (approval no.: DZMEC-KY-2020-40; Beijing, China).

2.2. Study population and setting

The data for this study were collected from December 2020 to December 2022 from patients with DF treated at Dongzhimen Hospital Beijing University of Chinese Medicine (Beijing, China), Beijing Hospital of Traditional Chinese Medicine (Beijing, China), First Teaching Hospital of Tianjin University of Traditional Chinese Medicine (Tianjin, China), Affiliated Hospital of Shandong University of Traditional Chinese Medicine (Ji'nan, China), and Shuguang Hospital Shanghai University of Traditional Chinese Medicine (Shanghai, China). To ensure the applicability and generalizability of the findings, the target population was defined as patients whose baseline characteristics were representative of typical DFI cases in China.

The study enrolled patients aged 18–75 years old with IDSA grade 2 DFU. Furthermore, the hemoglobin A1c level was ≤8%, ankle brachial index was ≥ 0.4, and ulcer area was between 1 × 1-cm^2 and 10 × 10-cm^2. Those who were allergic to interventions, used antibiotics within 1 week prior to treatment, had foot ulcers of non-diabetic etiology, severe hypoproteinemia, and cognitive impairment were excluded.

Participants were randomly allocated to the experimental or control group. All patients took part voluntarily and provided written informed consent before the trial began.

2.3. Comparators

The experimental group was treated with FHF (100 mL; National Drug Approval no.: Z10950097; Shandong Hanfang Pharmaceutical, Jinan, China), which was applied by soaking 10 layers of sterile gauze. After immersing the wound with the soaked gauze for 10 min, FHF was applied to the wound using two pieces of gauze and secured with a bandage. The dressing was changed once daily, and treatment continued for 2 weeks.

The control group used SAAAD (10 × 10-cm^2; National Medical Device Registration no.: 20183141645; Lohmann & Rauscher International GmbH & Co. KG, Schönau a.d. Triesting, Austria), which was applied to the wound surface and secured with a bandage, with dressings changed once daily, continued for 2 weeks.

According to the drug instructions, the ulcers were treated by applying gauze strips soaked in 10–20 mL of FHF. Assuming 15 mL of medication was used to soak and bandage the wound, each dressing change required 30 mL of FHF.

2.4. Perspective and time horizon

According to the China Guidelines for Pharmacoeconomic Evaluations (2020),[26] the costs measured in a cost-effectiveness analysis comprise direct medical, direct nonmedical, and indirect costs. Direct costs account for the largest proportion of the economic burden for patients with diabetes—approximately three times higher than indirect costs—with foot complications being the primary source of expenses.[6,27] DFI frequently occurs in patients with DFU, making it difficult to allocate the resulting indirect costs between the two conditions. Furthermore, the indirect costs associated with DFI are difficult to quantify. Given these circumstances, this study conducted the cost-effectiveness analysis from the perspective of the Chinese healthcare system.

The time horizon for this study was set at 2 weeks, based on the clinical trial duration and treatment guidelines. The clinical trial specified a 2-week observation period for patients with mild infections, consistent with treatment guidelines recommending 1–2 weeks of antibiotic therapy for mild DFI.[28] Therefore, the 2-week time horizon reasonably reflects the value of the intervention. Due to the short time horizon, this study did not consider discount rate.

2.5. Study parameters

From the Chinese healthcare system perspective, direct medical costs in this study included drug costs and dressing-change service fees. Drug prices were calculated using the 2023 bidding prices obtained from the Yaozh website (https://vip.yaozh.com/home, accessed June 14, 2024), based on the average unit price of the minimum specification. Dressing-change service fees were obtained from provincial medical insurance bureaus of 30 administrative regions, including Beijing, Tianjin, Shandong, and Shanghai, or from the bureaus of provincial capitals and other cities. All patients had wound areas less than 10 cm^2, classified as "small dressing changes" in the medical service price catalog. We calculated the total average prices of small-dressing change services in primary, secondary, and tertiary hospitals in each administrative region as unit costs. Direct medical costs were obtained by combining drug costs and dressing-change service fees for daily dressing changes over the 2-week period. The minimum unit prices of FHF and SAAAD and dressing-change service fees are listed in Table 1.

Quality-adjusted life years (QALYs) are standardized measures combining survival and health-related quality of life, where 1 QALY = 1 year of perfect health. The EuroQol Five-Dimension Three-Level (EQ-5D-3L) questionnaire was used to collect utility values from participants at baseline (before treatment) and at 2 weeks after treatment. The utility values for participants in the experimental and control groups at baseline and post-treatment were calculated based on the utility value set for the general population in China.[29] QALY was calculated using the following formula:

$$\text{QALYs} = (\text{post treatment utility value} + \text{baseline utility value}) \times \frac{1}{2} \times \frac{14}{365}$$

All parameters employed in this study are listed in Table 2.

2.6. Cost-effectiveness analysis

This study performed a cost-effectiveness analysis using QALYs as the health outcome. Costs were calculated based on drug expenses and dressing-change service fees incurred during the 2-week treatment period. The incremental cost-effectiveness ratio (ICER) and net monetary benefit (NMB) for the experimental and control groups were calculated.

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Table 1 Summary of minimum unit prices for medicines and dressing-change service fees

Parameter	Price (CNY)	Range	Distribution	Data source	Notes
Minimum unit price of FHF ($CNY \cdot mL^{-1}$)	0.38	0.38–0.39	Gamma	Yaozhi website	Average bidding prices in 2023
Minimum unit price of SAAAD ($CNY \cdot cm^{-2}$)	3.30	0.55–6.14	Gamma	Yaozhi website	Average bidding prices in 2023
Unit dressing-change service fee	12.35	3.00–24.00	Gamma	Medical Security Bureau	Average of 30 administrative regions

Notes: CNY: Chinese Yuan; FHF: Fufang Huangbai fluid; SAAAD: Suprasorb® A + Ag antimicrobial calcium alginate wound dressing.

Table 2 Parameters used in the cost-effectiveness analysis

Parameter	Baseline value	Lower value	Upper value	Distribution	Data source
Daily dosage					
FHF (mL)	30	27	33	Gamma	Drug instruction
SAAAD (cm^2)	10	9	11	Gamma	Drug instruction
Unit cost per dosage					
FHF ($CNY \cdot mL^{-1}$)	0.38	0.38	0.39	Gamma	2023 Yaozhi website bidding price
SAAAD ($CNY \cdot cm^{-2}$)	3.30	0.55	6.14	Gamma	2023 Yaozhi website bidding price
Daily dressing-change frequency					
FHF	1	0.90	1.1	Gamma	Drug instruction
SAAAD	1	0.90	1.1	Gamma	Drug instruction
Duration of treatment (days)					
FHF	14	12.60	15.40	Gamma	Clinical trial
SAAAD	14	12.60	15.40	Gamma	Clinical trial
Unit dressing-change service fee (CNY)	12.35	3	24	Gamma	Medical service prices of 30 regions
Baseline utility value					
FHF group	0.16	0.10	0.23	Beta	Clinical trial data
SAAAD group	0.19	0.13	0.25	Beta	Clinical trial data
Post-treatment utility value					
FHF group	0.49	0.43	0.54	Beta	Clinical trial data
SAAAD group	0.40	0.33	0.46	Beta	Clinical trial data

Notes: CNY: Chinese Yuan; FHF: Fufang Huangbai fluid; SAAAD: Suprasorb® A + Ag antimicrobial calcium alginate wound dressing.

$$\text{ICER} = \frac{\text{cost A} - \text{cost B}}{\text{effectiveness A} - \text{effectiveness B}}$$

$$\text{NMB} = \lambda \times \Delta\text{E} - \Delta\text{C}$$

where λ is the willingness-to-pay (WTP) threshold, $\Delta\text{E} = \text{effectiveness A} - \text{effectiveness B}$, $\Delta\text{C} = \text{cost A} - \text{cost B}$. A review on pharmacoeconomic studies on DF in the Chinese population (2020–2024) indicated that WTP values ranged from CNY 20 000–50 000 per QALY.[30,31] To fully reflect the cost-effectiveness of FHF for DFI, we set WTP at CNY 20 000 per QALY. The cost-effectiveness of the treatment was evaluated by comparing ICER and WTP: If ICER exceeds WTP, the treatment is not economical; otherwise, it is economical. When ICER and incremental cost were less than zero, NMB is used to calculate the net benefit.

The robustness of the results was assessed using deterministic sensitivity analysis (DSA) and probabilistic sensitivity analysis (PSA). In the DSA, the utility value range was set as the 95% confidence interval (CI), whereas drug prices and single dressing-change service fees were varied between their actual minimum and maximum values. Since dressing-change frequency, dosage, and treatment duration were fixed in this study, sensitivity analysis assumed ±10% variation from baseline values for these parameters. At a WTP threshold of CNY 20 000 per QALY, NMB was calculated using the upper and lower values of every parameter, and a tornado diagram was constructed. For PSA, the implementation of the bootstrap method was not feasible because complete individual patient data could not be obtained. As an alternative, a Monte Carlo simulation was conducted, assuming that the utility parameters followed a beta distribution and cost parameters followed a gamma distribution. Results were presented as incremental cost-effectiveness scatter plots and cost-effectiveness acceptability curves. Data analysis was performed using Microsoft Excel 2021 (Microsoft Corp., Redmond, WA).

3. Results

3.1. Basic analysis

A total of 234 participants were included in the study and randomly assigned to the experimental and control groups using a non-blinded method. Of these, 176 participants completed the experiment and provided valid data, with 86 and 90 participants in the FHF and SAAAD groups, respectively. The baseline and post-treatment utility values, 95% CIs, and QALYs for patients in the FHF and SAAAD groups are shown in Table 3. The distribution of utility values at baseline and post-treatment in the experimental and control groups is presented in Appendix 1. Cost information is summarized in Table 4.

Table 5 presents the results of cost-effectiveness analyses. Compared with the SAAAD group, the FHF group saved CNY 300.64 and gained an additional 0.0013 QALY, demonstrating an absolute advantage. At a WTP threshold of CNY 20 000 per QALY, the NMB was CNY 325.86, indicating that FHF has a cost-effectiveness advantage over SAAAD.

Table 3 Summary of utility value information

Treatment	Baseline utility	95% CI	Utility post-treatment	95% CI	QALYs
FHF	0.16	0.10–0.23	0.49	0.43–0.54	0.0125
SAAAD	0.19	0.13–0.25	0.40	0.33–0.46	0.0112

Notes: CI: confidence interval; FHF: Fufang Huangbai fluid; QALY: quality-adjusted life year; SAAAD: Suprasorb® A + Ag antimicrobial calcium alginate wound dressing.

Table 4 Summary of cost information

Treatment	Drug cost (CNY)	Dressing-change service fee (CNY)	Total cost (CNY)
FHF	161.36	172.91	334.27
SAAAD	462.00	172.91	634.91

Notes: CNY: Chinese Yuan; FHF: Fufang Huangbai fluid; SAAAD: Suprasorb® A + Ag antimicrobial calcium alginate wound dressing.

Table 5 Cost-effectiveness analysis of two treatments for diabetic foot infection

Treatment	Total cost (CNY)	Incremental cost (CNY)	health outcome (QALY)	Incremental QALY	ICER (CNY/QALY)	NMB (CNY)
FHF	334.27	-300.64	0.0125	0.0013	Absolute advantage	325.86
SAAAD	634.91		0.0112			

Notes: CNY: Chinese Yuan; FHF: Fufang Huangbai fluid; ICER: incremental cost-effectiveness ratio; NMB: net monetary benefit; QALY: quality-adjusted life year; SAAAD: Suprasorb® A + Ag antimicrobial calcium alginate wound dressing.

3.2. Sensitivity analysis

3.2.1. Deterministic sensitivity analysis

The results of DSA showed that the five parameters with the greatest impact on NMB were: the minimum unit price of SAAAD, daily dressing-change frequentcy with SAAAD, daily dosage of SAAAD (cm^2), duration of treatment with SAAAD, and daily dressing-change frequency with FHF. The latter four parameters had roughly equivalent impacts on the NMB. The minimum unit price of SAAAD produced the largest range of changes in NMB (Figure 1).

3.2.2. Probabilistic sensitivity analysis

The incremental cost-effectiveness scatter plot (Figure 2) showed that after 10 000 Monte Carlo simulations, most points fell in the fourth quadrant, with incremental costs ranging approximately from -1755.67 to 184.05 CNY and incremental effects ranging from -0.0121 to 0.0104 QALY. At a WTP of CNY 20 000 per QALY, the probability that FHF was cost-effectiveness was 70.65%, indicating that FHF was less expensive and more effective than SAAAD, with robust results.

The cost-effectiveness acceptability curve (Figure 3) shows that the probability of the FHF group having a cost-effectiveness advantage was consistently higher than that of the SAAAD group.

4. Discussion

Based on a healthcare system perspective, this study used a cost-effectiveness analysis to evaluate the economics of FHF and SAAAD for the treat-

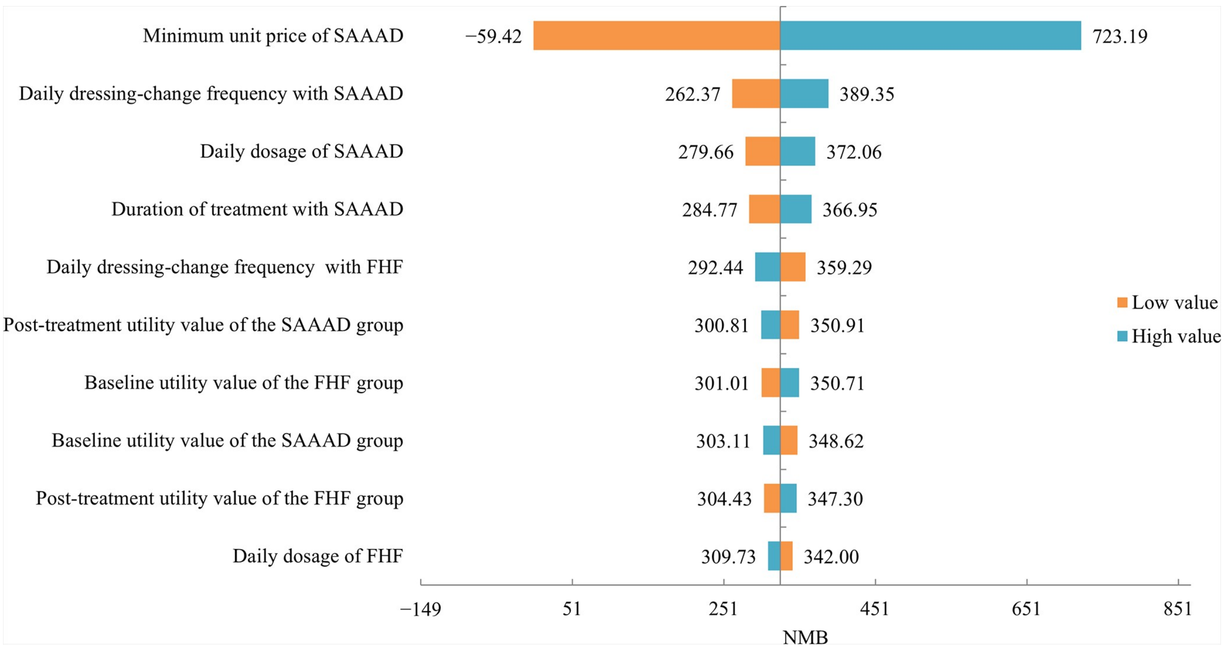

Figure 1 Tornado diagram of deterministic sensitivity analyses

Notes: FHF: Fufang Huangbai fluid; NMB: net monetary benefit; SAAAD: Suprasorb® A + Ag antimicrobial calcium alginate wound dressing.

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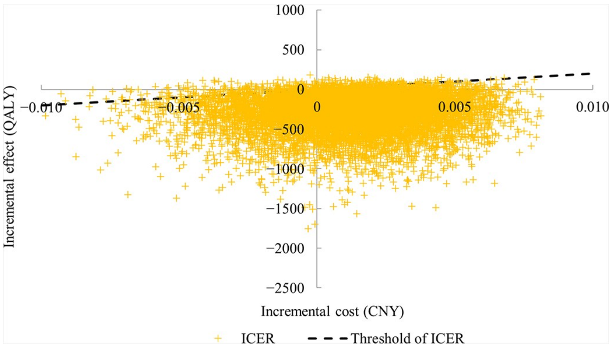

Figure 2 Incremental cost-effectiveness scatter plot

Notes: CNY: Chinese Yuan; ICER: incremental cost-effectiveness ratio; QALY: quality-adjusted life year.

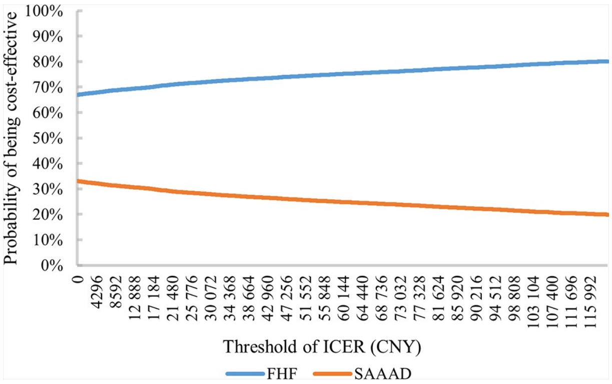

Figure 3 Cost-effectiveness acceptability curve

Notes: CNY: Chinese Yuan; FHF: Fufang Huangbai fluid; ICER: incremental cost-effectiveness ratio; SAAAD: Suprasorb® A + Ag antimicrobial calcium alginate wound dressing.

ment of drug-resistant bacterial infections in IWGDF/IDSA grade 1–2 DFUs. The results indicated that FHF saved CNY 300.64 in direct medical costs and gained 0.0013 QALY over a 2-week period, making it the dominant strategy. The DSA results suggested that the minimum unit price of SAAAD had the greatest impact on the NMB. The PSA results demonstrated that, at a WTP of CNY 20 000 per QALY, the probability that FHF was cost-effectiveness was 70.65%. The incremental cost-effectiveness acceptability curve showed that, when the WTP exceeded CNY 0 per QALY, the probability of FHF treatment having a cost-effectiveness advantage was higher than that of SAAAD. The results reveal the dual advantages of FHF in terms of both economic efficiency and therapeutic efficacy. In addition, this study addresses a critical gap in the economic evaluation of FHF for DFI treatment, providing an important scientific basis for optimizing healthcare resource allocation and informing health policy development.

DFI is a serious complication of diabetes, and the emergence of multidrug-resistant bacteria has further complicated clinical management,[32] often leading to increased healthcare costs and limited efficacy of conventional therapies. Existing cost-effectiveness analyses in this field have predominantly focused on treatment such as antibiotics, wound dressings, platelet-rich plasma, hyperbaric oxygen therapy, and negative pressure therapy.[33] However, the effectiveness of conventional antibiotics against drug-resistant pathogens is inherently limited. Platelet-rich plasma, commonly used as an adjuvant therapy, can enhance immune responses but may be restricted in widespread use due to high costs. Hyperbaric oxygen therapy and negative pressure therapy are also used as adjuvant therapies; however, they limit patient mobility during treatment. Furthermore, wound dressings are most suitable for patients with mild DFIs. FHF, a patented traditional Chinese medicine with confirmed broad-spectrum antibacterial effects, offers a promising alternative.

Moreover, utility values used in most existing cost-effectiveness analyses of DFI were derived from a 2004 public survey employing the time trade-off (TTO) method.[34] These data may not accurately reflect the current health preferences of patients with DFIs. Therefore, our study provides utility values obtained directly from a contemporary DFI population, which may enhance the accuracy of future economic evaluations. Our study fills a critical gap in cost-effectiveness analyses of topical traditional Chinese medicine preparations for DFI caused by resistant bacteria; however, some limitations should be acknowledged.

First, owing to the limited access to individual patient data and the short duration of the clinical trial, the IWGDF/IDSA grading of participants was not confirmed, and data on participants who underwent amputation during the trial were missing. Additionally, the 2-week duration of the trial precluded assessment of the potential amputation-related costs and utility reductions.

Second, there are limitations regarding the utility value collection. In a few cases, individual patient data showed that post-treatment utility values were lower than baseline values. The possible reasons for this discrepancy include biased participant understanding of the EQ-5D-3L questionnaire, resulting in suboptimal response data quality, and the potential worsening of infections in some participants. Because the utility values of the experimental and control groups were calculated as group means, the impact of individual outliers was minimal. However, owing to the short time horizon and the small absolute QALY gains, this still influenced the results.

Third, the utility values observed in this study were notably lower than those reported in previous research. Redekop et al.[34] and Huang[31] reported values of approximately 0.70 and 0.60 for DFI patients, respectively, whereas the baseline values in our cohort ranged only from 0.16 to 0.19. We hypothesized that this discrepancy could be attributed to several factors: the enrolled patients had a mean age of 65 years and suffered from both diabetes and foot ulcers, meaning the measured utilities likely reflected the compounded burden of multiple chronic conditions rather than DFI alone. Furthermore, whereas previous studies employed methods such as the TTO and visual analog scale (VAS), our study utilized the EQ-5D-3L questionnaire, which may have led to clustering of responses in the worst health states. Supporting this finding, EuroQol-VAS scores in our study were higher, with baseline means of 0.56–0.57, increasing to 0.71–0.76 post-treatment. Future research should consider using the more sensitive EQ-5D-5L to address this limitation.

Fourth, regarding costs, DFI treatment involves not only infection control, but also strict glycemic management and pressure-relief treatment for ulcerated wounds. This study simplified the treatment scenario by considering only drug costs and dressing-change service fees, without accounting for potential debridement procedures, their frequency, or amputation.

Fifth, we used a Monte Carlo simulation as an alternative, which may have introduced some deviations in the uncertainty analysis. Monte Carlo simulations assume distributions for cost and utility parameters rather than performing individual-based sampling, potentially limiting accurate simulation of real-world variation in costs and QALYs.[35] However, given the study population—patients with mild DFI over a very short period—the potential variation in both costs and health outcomes was inherently constrained. Moreover, given the minimal incremental cost and QALY observed, bootstrap methods may yield unstable or even meaningless results.[36] Consequently, within this specific context, the Monte Carlo simulation provides an acceptable approximation for assessing model parameter uncertainty.

5. Conclusion

This study establishes FHF as a cost-effective intervention for IWGDF/IDSA grade 1–2 DFIs, demonstrating both economic dominance and clinical effectiveness over antimicrobial dressings. The robust PSA (70.65% cost-effectiveness probability at a WTP threshold of CNY 20 000 per QALY) provides pivotal evidence supporting the integration of traditional Chinese medicine into standardized DF management protocols.

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Author Contribution Statement

Yu-chen Gong: Methodology, data curation, writing – original draft, and writing – review & editing. **Chu-chuan Wan:** Methodology, data curation, formal analysis, and writing – review & editing. **Peng-cheng Tang:** Data curation and investigation. **Xiao-yu Xi:** Conceptualization, supervision, and writing – review & editing. **Gang Wang:** Conceptualization, supervision, and writing – review & editing.

Declaration of Competing Interest

The authors have no competing interests to declare that are relevant to the content of this article.

Electronic Supplementary Material

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References

[1] Xu L, Fan WJ, Wang XH, Liu GB. Clinical observation on treatment of diabetic foot ulcer of Wagner grade 1–2 by compound huangbai liquid fomentation. *Chin J Exp Tradit Med Form*. 2023;29(6):104−110.

[2] Chinese Society of Endocrinology, China Endocrine and Metabolic Disease Specialist Alliance. Expert consensus on wound treatment of diabetic foot ulcer (2024). *Chin J Endocrinol Metab*. 2024;40(7):565−569.

[3] van Netten JJ, Bus SA, Apelqvist J, et al. Definitions and criteria for diabetes-related foot disease (IWGDF 2023 update). *Diabetes Metab Res Rev*. 2024;40(3):e3654.

[4] GBD 2021 Diabetes Collaborators. Global, regional, and national burden of diabetes from 1990 to 2021, with projections of prevalence to 2050: a systematic analysis for the Global Burden of Disease Study 2021. *Lancet*. 2023;402(10397):203−234.

[5] Zhou YC, Liu JM, Zhao ZP, Zhou MG, Ng M. The national and provincial prevalence and non-fatal burdens of diabetes in China from 2005 to 2023 with projections of prevalence to 2050. *Mil Med Res*. 2025;12(1):28.

[6] McDermott K, Fang M, Boulton AJM, Selvin E, Hicks CW. Etiology, epidemiology, and disparities in the burden of diabetic foot ulcers. *Diabetes Care*. 2023;46(1):209−221.

[7] Sun H, Saeedi P, Karuranga S, et al. IDF Diabetes Atlas: global, regional and country-level diabetes prevalence estimates for 2021 and projections for 2045. *Diabetes Res Clin Pract*. 2022;183:109119.

[8] IDF diabetes atlas 2021. International Diabetes Federation Web site. https://diabetesatlas.org/atlas/tenth-edition. Accessed August. 12, 2024.

[9] Chinese Diabetes Society, Chinese Society of Infectious Diseases, Chinese Society for Tissue Repair and Regeneration. Chinese guideline on prevention and management of diabetic foot (2019 edition) (Ⅰ). *Chin J Diabetes Mellitus*. 2019;11(2):92−108.

[10] Jodheea-Jutton A, Hindocha S, Bhaw-Luximon A. Health economics of diabetic foot ulcer and recent trends to accelerate treatment. *Foot*. 2022;52:101909.

[11] Senneville É, Albalawi Z, van Asten SA, et al. IWGDF/IDSA guidelines on the diagnosis and treatment of diabetes-related foot infections (IWGDF/IDSA 2023). *Diabetes Metab Res Rev*. 2024;40(3):e3687.

[12] Hu WW, Lin YT. Alginate/polycaprolactone composite fibers as multifunctional wound dressings. *Carbohydr Polym*. 2022;289:119440.

[13] Li J, Wu L, Cai T, Cao Y, Jiang Y. Research progress of *Cortex Phellodendri* in the chemical constituents and their pharmacological effects. *J Pharm Pract*. 2018;36(5):389−391,398.

[14] Wang L, Du X, Zhu HL, Wu P. Review of pharmacological actions of effective components of *Phellodendron* Chinense. *Jiangsu J Tradit Chin Med*. 2022;54(4):77−81.

[15] Shi ZW, Hao JJ, Zhen HX, Zhao HM. Comparative analysis of active constituents of *Forsythia suspensa* and its antioxidative and antimicrobial properties. *Mol Plant Breed*. 2023;21(9):3057−3064.

[16] Liu XY, Sheng DQ. Research progress in the antibacterial effect of active ingredients of *Lonicerae japonicae* Flos. *Anti Infect Pharm*. 2023;20(8):783−789.

[17] Qi JJ, Ma MY, Song SQ. Research progress on antibacterial and antiviral effect and clinical application of dandelion. *Shandong Chem Ind*. 2022;51(13):76−79.

[18] Lu J, Deng QP, Ren WH. Mechanism of antimicrobial peptide scolopin 2-NH2 isolated from Scolopendra subspinipes mutilans. *Biotechnol Bull*. 2018;34(11):179−190.

[19] Zou LJ, Li BH. Comparison of clinical effect of Fufang Huangbai Ye and povidone-iodine in treatment of diabetic foot infection. *Chin J Biochem Pharm*. 2016;36(5):171−173.

[20] Wu YY. *Clinical Efficacy of Compound Huangbai Liquid Coating Applied Externally to Diabetic Foot Ulcers* [master's thesis]. Hefei, China: Anhui University of Chinese Medicine; 2025.

[21] Xu B, Wang J, Sun MM, Cao YY. Observation on the efficacy of compound Huangbai liquid solution applied externally to control the infection of multiple drug-resistant bacteria in diabetes foot. *Chin J Surg Integr Tradit West Med*. 2023;29(3):293−298,306.

[22] Wang LX, Huang RY, Liu GB. Efficacy of an externally applied agent, compound cortex phellodendri liquid, for the treatment of Wagner grade 2–3 diabetic foot ulcers *via* combined wet compress therapy and dipping bath and its influence on serum inflammatory factors. *J Anhui Univ Chin Med*. 2023;42(1):36−39.

[23] Barbu A, Neamtu B, Zăhan M, Iancu GM, Bacila C, Mireşan V. Current trends in advanced alginate-based wound dressings for chronic wounds. *J Pers Med*. 2021;11(9):890.

[24] Umar M, Ullah A, Nawaz H, et al. Wet-spun bi-component alginate based hydrogel fibers: development and *in-vitro* evaluation as a potential moist wound care dressing. *Int J Biol Macromol*. 2021;168:601−610.

[25] Dini G, Cilasun GE, Kuruca SE, Gürarslan A. Fabrication and characterization of silver nanowire-coated porous alginate wet-laid webs for wound dressing applications. *Int J Biol Macromol*. 2025;296:139770.

[26] Liu GE. *China Guidelines for Pharmacoeconomic Evaluations (2020)*. Beijing, China: China Market Press; 2020: 5–55.

[27] Hou QT, Li Y, Li SY, Tian HM. The global burden of diabetes mellitus. *Chin J Diabetes*. 2016;24(1):92−96.

[28] Chinese Diabetes Society, Chinese Society of Infectious Diseases, Chinese Society for Tissue Repair and Regeneration. Chinese guideline on prevention and management of diabetic foot (2019 edition) (Ⅲ). *Chin J Diabetes Mellitus*. 2019;11(4):238−247.

[29] Liu GG, Wu HY, Li MH, Gao C, Luo N. Chinese time trade-off values for EQ-5D health states. *Value Health*. 2014;17(5):597−604.

[30] Li XJ, Gao SN, Liu GQ. Pharmacoeconomic evaluation of pentoxifylline sustained release tablets in the treatment of diabetic foot. *China J Pharm Econ*. 2022;17(8):11−15.

[31] Huang Y. *Health Economic Evaluation of MDT Mode of Diabetic Foot Based on Markov Model* [master's thesis]. Guangzhou, China: Southern Medical University; 2020.

[32] He J, Qing F, Wen B, Liu S, Gui L, Zhu H. Research progress on drug resistance characteristics and treatment of pathogenic bacteria in patients with diabetic foot infection. *Int J Clin Res*. 2025;9(3):45−50.

[33] Woods TJ, Tesfay F, Speck P, Kaambwa B. Economic evaluations considering costs and outcomes of diabetic foot ulcer infections: a systematic review. *PLoS One*. 2020;15(4):e0232395.

[34] Redekop WK, Stolk EA, Kok E, Lovas K, Kalo Z, Busschbach JJV. Diabetic foot ulcers and amputations: estimates of health utility for use in cost-effectiveness analyses of new treatments. *Diabetes Metab*. 2004;30(6):549−556.

[35] Pasta DJ, Taylor JL, Henning JM. Probabilistic sensitivity analysis incorporating the bootstrap: an example comparing treatments for the eradication of Helicobacter pylori. *Med Decis Making*. 1999;19(3):353−363.

[36] Xie Y, Zong X, Sun LH. Application of non-parametric bootstrap method in the evaluation of confidence intervals of cost-effectiveness. *China Pharm*. 2010;21(22):2027−2029.