Clinical Drug Investigation (2025) 45:283–294
https://doi.org/10.1007/s40261-025-01439-6

ORIGINAL RESEARCH ARTICLE

Economic Evaluation of Penpulimab Plus Paclitaxel and Carboplatin Combination Therapy as First-Line Treatment for Locally Advanced or Metastatic Squamous Non-small Cell Lung Cancer in China

Meng Han[1] · Hye-In Jung[2] · Yong-Fa Chen[1] · Eui-Kyung Lee[2]

Accepted: 7 April 2025 / Published online: 21 April 2025

Abstract

Introduction Penpulimab is a PD-1 monoclonal antibody recommended for treating squamous non-small cell lung cancer (sqNSCLC) in combination with paclitaxel and carboplatin. This study aimed to assess the cost-effectiveness of penpulimab combined with paclitaxel and carboplatin against paclitaxel plus carboplatin as first-line treatment for locally advanced or metastatic sqNSCLC in China.

Methods A three-state partitioned survival model was constructed using the efficacy outcomes obtained by digitizing the AK105-302 trial and was extrapolated to the lifetime horizon. Data on direct medical costs and utilities was gathered from the literature and commercial databases from the perspective of the Chinese healthcare system. Outcomes included quality-adjusted life years (QALYs), life years (LYs), and the incremental cost-effectiveness ratio (ICER). Sensitivity analysis and scenario analysis were performed to test the model robustness.

Results The incremental efficacy of penpulimab plus paclitaxel and carboplatin was 0.821 QALYs and 1.176 LYs with an incremental cost of $20,335 compared with paclitaxel plus carboplatin combination therapy. The ICER was $24,778 per QALY, falling below the threshold of three times the per capita gross domestic product of China, a commonly applied benchmark. The results of the one-way sensitivity analysis demonstrated that the ICER values were primarily influenced by the utility of progression-free state and cost of penpulimab. Probabilistic sensitivity analysis showed that penpulimab plus paclitaxel and carboplatin was cost-effective for 98.3% of the cases. Scenario analysis yielded results similar to those of the base–case analysis.

Conclusions Our analysis suggests that penpulimab plus paclitaxel and carboplatin combination therapy is cost-effective for patients with locally advanced or metastatic sqNSCLC in China.

1 Introduction

Lung cancer stands as the predominant malignancy in China in regard to both its incidence and mortality rates, with non-small cell lung cancer (NSCLC) accounting for approximately 85% of all lung cancer cases [1]. More than 70% of patients with NSCLC are diagnosed with locally advanced or metastatic disease at diagnosis [2]. Approximately one-third of patients with NSCLC are diagnosed at the unresectable stage [3]. Squamous NSCLC (sqNSCLC) accounts for approximately 20–30% of NSCLC cases [4]. As first-line treatment, patients ineligible for targeted therapy may require chemotherapy

Meng Han, Hye-In Jung are Co-first author.

✉ Yong-Fa Chen
cyf990@163.com

✉ Eui-Kyung Lee
ekyung@skku.edu

[1] School of International Pharmaceutical Business, China Pharmaceutical University, No. 639 Longmian Avenue, Jiangning District, Nanjing 210009, Jiangsu, People's Republic of China

[2] School of Pharmacy, Sungkyunkwan University, 2066, Seobu-ro, Jangan-gu, Suwon-si, Gyeonggi-do 16419, Republic of Korea

Key Points

This study evaluates the cost-effectiveness of penpulimab combined with paclitaxel and carboplatin against paclitaxel plus carboplatin as first-line treatment for locally advanced or metastatic sqNSCLC within the Chinese healthcare system, utilizing results from the AK105-302 trial and incorporating China-specific cost data.

Findings indicate substantial benefits in QALYs, especially for the positive PD-L1 subgroup patients, with an ICER of $24,778 per QALY for the general cohort and $20,527 per QALY for the positive PD-L1 subgroup patients.

The results provide insights to clinicians and policymakers in optimizing treatment decisions for locally advanced or metastatic sqNSCLC within Chinese healthcare system.

or immunotherapy to prolong survival. [5] The Guidelines of the Chinese Society of Clinical Oncology (CSCO) Non-Small Cell Lung Cancer (2023 version) recommend therapies for treating patients with locally advanced or metastatic sqNSCLC using chemotherapy with or without pembrolizumab, camrelizumab, sintilimab, tislelizumab, sugemalimab, serplulimab, and penpulimab [6]. Although several immunotherapies are available, chemotherapy has been the mainstay treatment for advanced NSCLC [4] according to a 2020 survey on the treatment pattern of NSCLC in China [7].

Different from other immunotherapies, Penpulimab, a novel programmed cell death protein 1 (PD-1) monoclonal antibody that uses the immunoglobulin G1 subtype with fragment crystallizable region modifications, is currently marketed in China [8]. It eliminates antibody-dependent cell-mediated cytotoxicity and complement-dependent cytotoxicity, abrogates antibody-dependent cellular phagocytosis, and reduces antibody-dependent cytokine release effects [8]. Moreover, patients with high programmed cell death-ligand 1 (PD-L1) expression are predicted to benefit more from the treatment. Cancer cells that highly express PD-L1 bind more efficiently to the PD-1 protein on T cells, thereby inhibiting their antitumor activity [9]. The results of a pivotal trial (AK105-302) demonstrated that patients with locally advanced or metastatic sqNSCLC receiving penpulimab plus paclitaxel and carboplatin combination therapy had superior median progression-free survival (PFS) compared with those treated with paclitaxel plus carboplatin (7.6 months versus 4.2 months). Among patients with a positive PD-L1 expression, there was a 63% reduction in the risk of disease progression or death [10].

In January 2023, the National Medical Products Administration (NMPA) approved the use of penpulimab plus paclitaxel and carboplatin combination therapy as first-line treatment for patients with locally advanced or metastatic sqNSCLC. In the same year, the CSCO released the Guidelines of CSCO Non-Small Cell Lung Cancer (2023 version), which assigned a level I recommendation to penpulimab plus paclitaxel and carboplatin combination therapy as a first-line treatment [6]. However, the clinical application of penpulimab is still in its early stages, and further comprehensive evaluations of its efficacy, safety, and economic burden are needed [8].

Considering the growing use of immunotherapy within Chinese healthcare system and the limited healthcare resources [11], the high treatment cost of immunotherapy may impact the adequate distribution of healthcare resources. Therefore, the assessment of the efficacy and the economic burden of newly approved immunotherapies for advanced sqNSCLC treatment is crucial. To the best of our knowledge, the penpulimab plus paclitaxel and carboplatin combination therapy in China has not been evaluated yet. The absence of cost-effectiveness analysis from the Chinese perspective has partially impeded the utilization of penpulimab [12]. Hence, this study was conducted to evaluate the cost-effectiveness of penpulimab plus paclitaxel and carboplatin combination therapy as first-line treatment for locally advanced or metastatic sqNSCLC from the perspective of the Chinese healthcare system.

2 Methods

2.1 Model Structure

We used the partitioned survival model (PSM) to simulate the health status of patients with locally advanced or metastatic sqNSCLC at different timepoints, including, PFS progressive disease (PD), and death. Since paclitaxel plus carboplatin is the most frequently utilized treatment for first-line therapy of sqNSCLC, it was used as a comparator [13]. Therefore, the following two compared regimens were compared: (1) penpulimab plus paclitaxel and carboplatin combination therapy (penpulimab strategy) and (2) paclitaxel plus carboplatin combination therapy (chemotherapy strategy). In each cycle, the population in each health state was represented by the area under the curve (AUC) of non-mutually exclusive populations drawn from the PFS and overall survival (OS) curves. At the onset of the simulation, all patients were in the PFS state. They had

three options at the end of each therapy cycle: remaining in the PFS state, deteriorate to the progressive disease state, or die. Patients could stay in the progressive disease state or enter the death state. However, they could not return to the PFS state.

The cycle length followed the approved treatment schedule for penpulimab, which is 21 days, and the time horizon was the lifetime. The time horizon spanned the entire lifetime to ensure that the number of survivors was less than 1% from the OS curve of the chemotherapy strategy, which was 8 years. The costs and effectiveness in this study were modified by applying a 5% annual discount rate in accordance with the Guidelines for Pharmacoeconomic Evaluation in China [14]. This study utilized Microsoft Excel 2019 software to construct the PSM and perform a cost-effectiveness analysis.

2.2 Patient Cohort

The target population included adults with locally advanced (stage IIIb or IIIc) or metastatic (stage IV) sqNSCLC who had not previously received systemic therapy. The patients in our study were derived according to eligibility criteria from the AK105-302 trial. The patients were assumed to have a negative subtype of epidermal growth factor receptor (EGFR)-sensitive mutations or anaplastic lymphoma kinase translocation. They received 200 mg of penpulimab [15] plus 175 mg/m^2 of paclitaxel [16] and 625 mg of carboplatin (target AUC: 5) [17] in the penpulimab strategy, and 175 mg/m^2 of paclitaxel and 625 mg of carboplatin in the chemotherapy strategy. The regimens were assumed to be continued until disease progression, death, or the completion of 24 months of treatment.

In the PD state, patients were assumed to receive 75 mg/m^2 of docetaxel as second-line treatment in both groups on the basis of clinical guidelines [18] and published literature [19,20].

2.3 Model Probabilities

OS and PFS curves were obtained by digitizing the results of the AK105-302 trial using WebPlotDigitizer software version 4.8. Following the approach outlined by Guyot et al. [21] individual patient data were reconstructed from Kaplan–Meier (KM) survival curves using the R software (version 4.1.3). The reconstructed KM curves were visually inspected and compared with those reported in the literature to assess the reliability of median OS and median PFS. To determine the long-term effectiveness over a lifetime, the parametric method was applied to calculate the survival function.

Whether the parametric distributions should be fitted dependently or independently of the OS and PFS curves was assessed using the proportional hazard (PH) assumption [22]. The KM curves of both OS and PFS violated the PH assumption in graphical analysis using log-cumulative hazard plots and goodness-of-fit tests [23,24]. Therefore, the best-fitting distribution for each KM curve was selected independently.

To infer the long-term OS and PFS curves after the follow-up period, various standard parametric distributions, such as exponential, Weibull, gamma, Gompertz, log-logistic, log-normal, and generalized gamma, were fitted to the reconstructed KM curves. Some literature insists that these models frequently lack the necessary flexibility to accurately capture the long-term outcomes expected with immune checkpoint inhibitors (ICIs) [25,26]. Therefore, we included a 2-knot restricted cubic spline on the table. The restricted cubic spline model allows further representation of the complexity underlying hazards in a unique time-course of the treatment response [27]. They enable hazard and survival functions with complex shapes to be accurately modeled [28]. Spline models with 2-knots on the PH, the proportional odds (PO), and the probit were adapted using the automatic knot placement. [29] The best-fit distribution was selected by assessing the Akaike information criterion, Bayesian information criterion, and visual examination (Supplementary Table S1).

The OS curve for the penpulimab strategy was simulated using log-logistic and gamma distributions for the OS of the chemotherapy strategy. The PFS curves of the penpulimab strategy employed a 2-knot spline distribution, and a 2-knot spline PO distribution was used for the PFS curve of the chemotherapy strategy (Fig. 1). For the PFS of the positive PD-L1 subgroup, the penpulimab strategy employed a 2-knot spline distribution, and a 2-knot spline PH distribution was used for the chemotherapy strategy.

2.4 Cost

From the perspective of the Chinese healthcare system, our analysis included direct medical costs related to the treatment and care of locally advanced or metastatic sqNSCLC patients in China. These included drug costs, follow-up costs, drug administration costs, subsequent treatment costs (after disease progression), adverse events (AEs) costs, and end-of-life care costs. All costs were converted from Chinese yuan (CNY) to US dollars (USD) using the 2023 exchange rate (1 USD = 7.0467 CNY) [30].

Drug costs were determined according to the approved dosing regimens. Since penpulimab was not listed on the current National Reimbursement Drug List (NRDL), the cost of penpulimab was determined using the mean local bid-winning price [31]. The prices of all other drugs used the mean price from the national centralized drug procurement [32]. The glomerular filtration rate (GFR) of 100 mL/min,

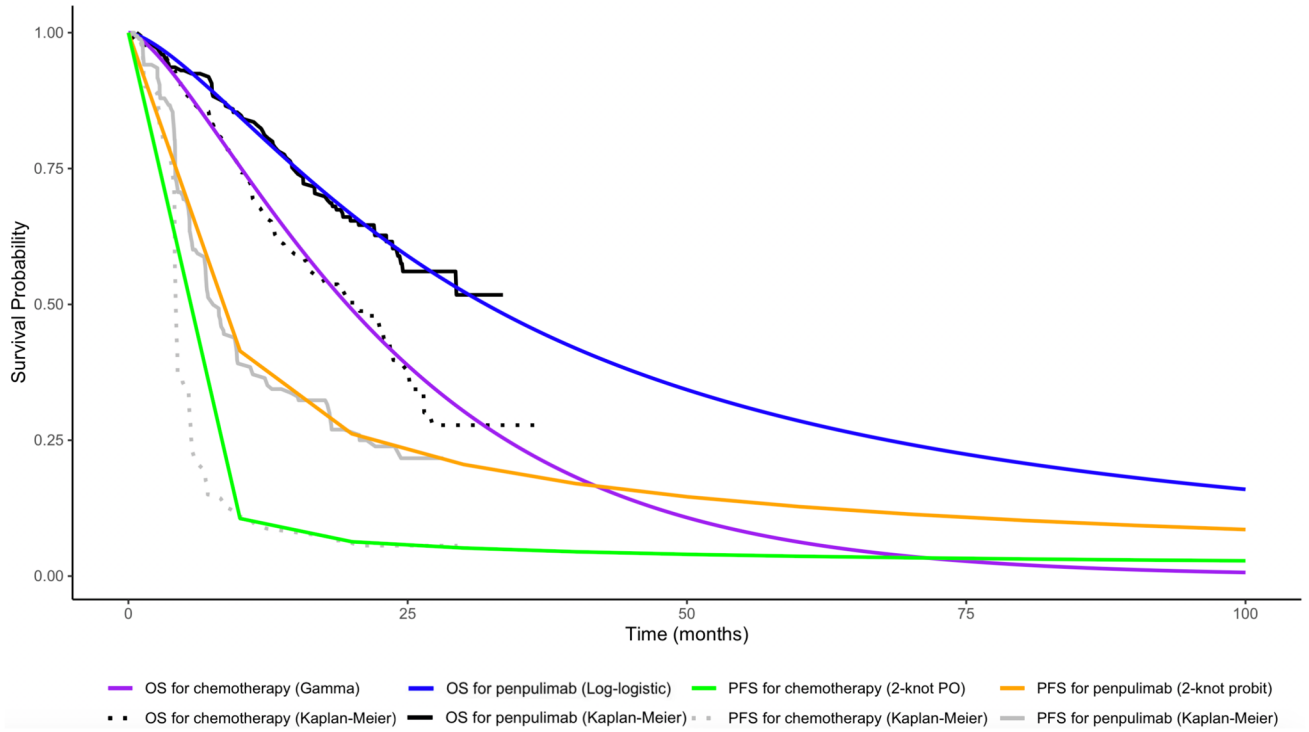

Fig. 1 PFS Curve and OS Curve Fitting and Extrapolation in the Penpulimab Strategy and Chemotherapy Strategy. *PFS* progression-free survival, *PO* proportional odds, *OS* overall survival

which is the median value of the normal range of 80–120 mL/min, and a body surface area of 1.72 m^2 were considered to calculate the costs of paclitaxel and carboplatin. These assumptions were based on the average height of 164 cm and weight of 65 kg in the Chinese population [33–35].

Follow-up costs included regular enhanced computed tomography and laboratory tests (vital signs, 12-lead electrocardiogram, routine blood tests, urine tests, biochemistry tests, and thyroid function tests). Drug administration costs included consultation fees, intravenous infusion fees, bedding fees and nursing fees. The follow-up and drug administration costs used the mean value of each item in the healthcare price lists across 15 provinces [36–50]. Subsequent treatment costs following disease progression included docetaxel and related drug administration costs.

Regarding AE costs, this study involved grade 3 to higher AEs with an incidence rate exceeding 3% from the AK105-302 trial. These AEs includes neutrophil count decreased, white blood cell decreased, hypertriglyceridemia, alanine aminotransferase increased and platelet count decreased. The cost of AEs was determined by multiplying the cost of AEs per cycle by their incidence. On the basis of clinical practice, white blood cell decreased and neutrophil count decreased are considered moderate AEs and typically do not require additional treatment [51]. Hence, the costs of AEs costs were not included in the overall cost. Management strategies for other AEs were based on the AK105-302 trial or guidelines [10,52,53]. AE-related drugs, diagnosis fees, follow-up fees, and administration fees were obtained from national centralized drug procurement [32]. The cost of end-of-life care was obtained from a previous study conducted in the Chinese cancer population [54]. The detailed costs are listed in Table 1.

2.5 Health Utility

Health utility values were derived from the study conducted by Nafees et al. [55] in the Chinese population. The utility values for the PFS are 0.804, and the utility value for the PD states are 0.321.

2.6 Cost-Effectiveness Analysis

Outcomes included life years (LYs), quality-adjusted life years (QALYs), and the incremental cost-effectiveness ratio (ICER). ICER is the ratio of the incremental cost to the incremental effectiveness of treatment [56]. According to the willingness-to-pay (WTP) outlined in the Guidelines for Pharmacoeconomic Evaluation in China [14], we used three times per capita gross domestic product (GDP) of

Table 1 Key Model Parameters

Model inputs	Expected value(range)	Distribution	Source
Survival model for penpulimab strategy			
Log-logistic model for OS	Scale = 32.012, shape = 1.458	Log-logistic	[10]
2-knot probit model for PFS	gamma0 = −2.245, gamma1 = 0.836, gamma2 = −0.461, gamma3 = 0.575	Log-normal	[10]
Survival model for chemotherapy strategy			
Gamma model for OS	Rate = 0.062, shape = 1.523	Gamma	[10]
2-knot PO model for PFS	gamma0 = −4.202, gamma1 = 1.010, gamma2 = −19.023, gamma3 = 19.318	Log-logistic	[10]
Quality of life			
Utility of PFS	0.804 (0.643–0.965)	Beta	[55]
Utility of progressed disease	0.321 (0.257–0.385)	Beta	[55]
Drug costs $/cycle			
Penpulimab	1226.02 (1013.24–1383.63)	Gamma	[31]
Paclitaxel	490.98 (392.89–589.10)	Gamma	[32]
Carboplatin	63.75(50.99–76.46)	Gamma	[32]
Subsequent treatment cost	64.17 (32.74–96.00)	Gamma	[32]
Follow-up costs, $/event			
Enhanced computed tomography	118.86 (57.47–289.50)	Gamma	Healthcare price list[a]
Vital signs	0.78 (0.14–1.42)	Gamma	
12-lead electrocardiography	3.47 (1.42–5.11)	Gamma	
Blood chemistry	27.37 (16.75–48.11)	Gamma	
Thyroid function	14.52 (7.38–26.25)	Gamma	
Urinalysis	1.00 (0.43–2.55)	Gamma	
Hematology	2.55 (1.06–3.83)	Gamma	
Coagulation parameters	4.44 (1.06–6.39)	Gamma	
Drug administration costs, $/event			
Diagnosis	1.93 (0.57–7.10)	Gamma	Healthcare price list[a]
IV injection	0.85 (0.64–1.14)	Gamma	
Nursing	2.16 (0.85–4.26)	Gamma	
Bedding	4.93 (1.42–8.52)	Gamma	
Adverse events costs, $/event			
Hypertriglyceridaemia	15.16 (7.94–24.14)	Gamma	[32]
Platelet count decreased aminotransferase	681.20 (621.13–763.91)	Gamma	
Alanine aminotransferase increased	400.91 (168.63–634.55)	Gamma	
End-of-life care cost	2085.00 (2019.00–2522.00)	Gamma	[54]
Discount rate	0.05 (0.00–0.08)	Beta	[[14,60]]

PFS progression-free survival, *OS* overall survival, *PO* proportional odds, *IV* intravenous

[a]Healthcare price list: from the list of medical service price items of 15 provinces (average value). The 15 provinces are Zhejiang, Beijing, Shaanxi, Shanghai, Tianjin, Sichuan, Shandong, Jiangsu, Guangdong, Hunan, Hubei, Anhui, Henan, Hebei, and Jilin

China in 2023 ($38,071 per QALY) as the WTP threshold [57].

2.7 Subgroup Analysis

We conducted a subgroup analysis on patients with positive PD-L1 expression (PD-L1 tumor proportion score ≥ 1%). The PFS curves of the subgroups from a pivotal trial were reconstructed and their long-term efficacy was extrapolated. Since no published KM curve of OS for the patients with positive PD-L1 existed, the OS was presumed to be equivalent to the base–case population.

Table 2 Results of Base–Case Analysis

	Cost	QALYs	LYs	ICER
Base–case				
Penpulimab strategy	$27,189	1.752	3.089	$24,778/QALY
Chemotherapy strategy	$6855	0.932	1.913	
Positive PD-L1 subgroup				
Penpulimab strategy	$27,654	1.892	3.089	$20,527/QALY
Chemotherapy strategy	$6772	0.875	1.913	

LYs life-years, *ICER* incremental cost-effectiveness ratio, *QALYs* quality-adjusted life-years, *PD-L1* programmed cell death ligand 1

2.8 Sensitivity Analysis

We performed sensitivity analyses to examine model uncertainty. In the one-way sensitivity analysis, data from the original research report served as the foundation for determining the range of parameter variations in the analysis. All parameters were sequentially modified to their original data sources or predefined lower and upper values to identify those parameters significantly influencing the model outputs. An assumption of plus or minus 20% was made for the time horizon parameter [58]. The annual discount rates vary from 0 to 8% [14]. One-way sensitivity analysis results are depicted using tornado diagrams, with parameters ranked according to their decreasing influence on evaluation outcomes.

In the probabilistic sensitivity analysis (PSA), a Monte Carlo simulation with 1000 iterations was conducted, where each simulation involved random sampling of all parameter distributions. The utility parameters have a beta distribution whereas the cost parameters have a gamma distribution [59]. A cost-effectiveness acceptability curve (CEAC) was constructed to illustrate the probability of the intervention being considered cost-effective across varying WTP thresholds.

Additionally, we conducted scenario analyses using a 2-knot PO model to evaluate the impact of alternative distributions on the ICER. When fitting distributions to PFS curves, both the 2-knot probit and 2-knot PO models were found to be ranked first (Supplementary Fig. S1). On the basis of visual inspection, the 2-knot PO model was considered a reasonable alternative to the 2-knot probit model in the PFS curves for the penpulimab strategy.

3 Results

3.1 Base–Case Analysis

Table 2 presents the base–case results of the PSM. During the simulated timeframe, patients in the penpulimab strategy gained an additional 0.821 QALYs (1.752 versus 0.932) and 1.176 LYs (3.089 versus 1.913) compared with those in the chemotherapy strategy. The incremental cost was $20,335 ($27,189 versus $6855), yielding an ICER value of $24,778 per QALY. These findings indicate that the ICER was below the willingness-to-pay threshold, highlighting that first-line treatment with the penpulimab plus paclitaxel and carboplatin combination therapy for the patients with in locally advanced or metastatic sqNSCLC is cost-effective.

3.2 Subgroup Analysis

In the positive PD-L1 subgroup analysis, patients in the penpulimab strategy gained an additional 1.017 QALYs (1.892 versus 0.875) and 1.176 LYs (3.089 versus 1.913) compared with the chemotherapy strategy. The incremental cost was $20,882 ($27,654 versus $6772). Therefore, penpulimab plus paclitaxel and carboplatin combination therapy in the positive PD-L1 subgroup remained cost-effective compared with paclitaxel and carboplatin combination therapy and showed even lower ICER, with a value of $20,527 per QALY (Table 2).

3.3 Sensitivity Analysis

In the one-way sensitivity analysis (Fig. 2), the most influential factors for the base–case analysis were found to be the utility values of the PFS state, cost of penpulimab, and time horizon.

The PSA results (refer to Fig. 3) indicated that the probability of cost-effectiveness for the penpulimab plus paclitaxel and carboplatin combination therapy was 98.3% at a WTP threshold of three times the per capita GDP. Furthermore, the CEAC presented in Fig. 4 illustrates the cost-effectiveness of the penpulimab strategy as the first-line treatment of locally advanced or metastatic sqNSCLC increased as the WTP value increased. At a WTP value of $24,746 per QALY, the penpulimab strategy and chemotherapy strategy have an equal probability of being cost-effective. The probability of penpulimab strategy being cost-effective approaches 100% when the WTP is $45,685 per QALY.

In the scenario analysis, applying 2-knot spline PO model fit to the PFS curve of the penpulimab strategy resulted in a lower ICER ($24,778 per QALY versus

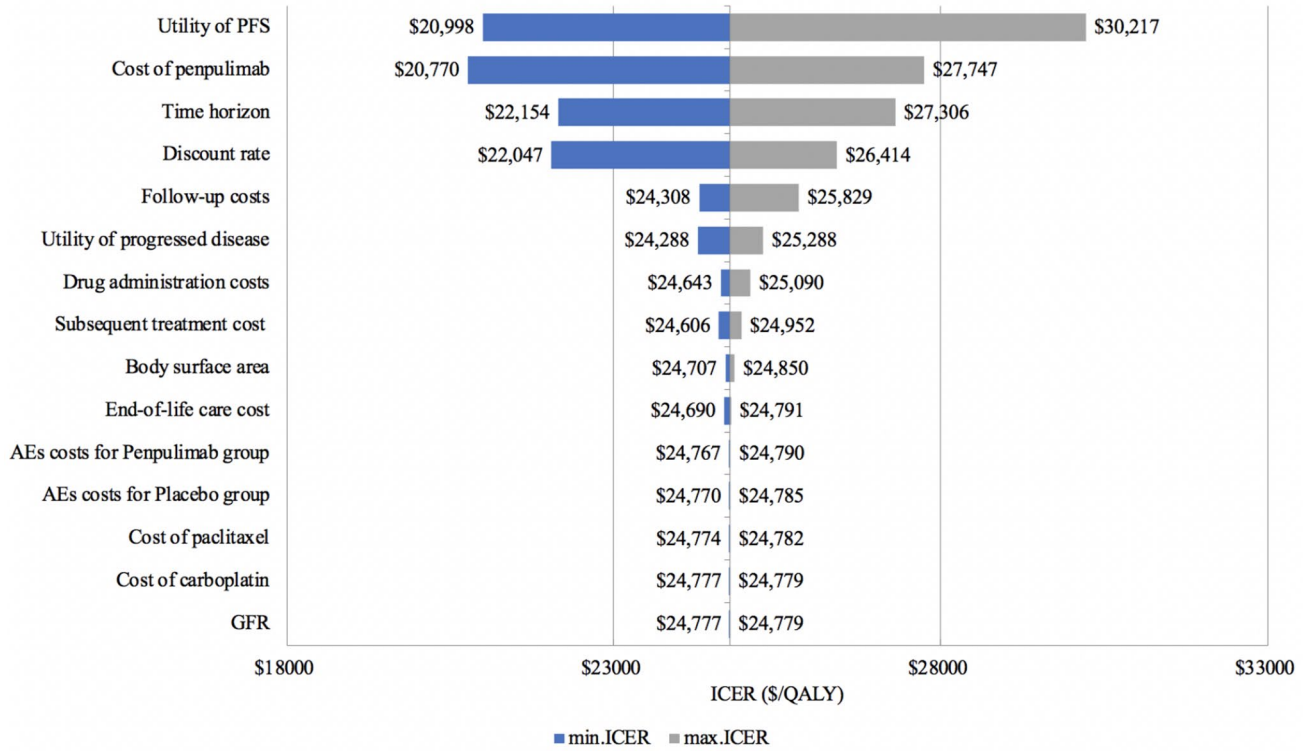

Fig. 2 One-way sensitivity analysis of cost-effectiveness comparison of penpulimab strategy and chemotherapy strategy. *ICER* incremental cost-effectiveness ratio, *PFS* progression-free survival, *AEs* adverse events, *GFR* glomerular filtration rate

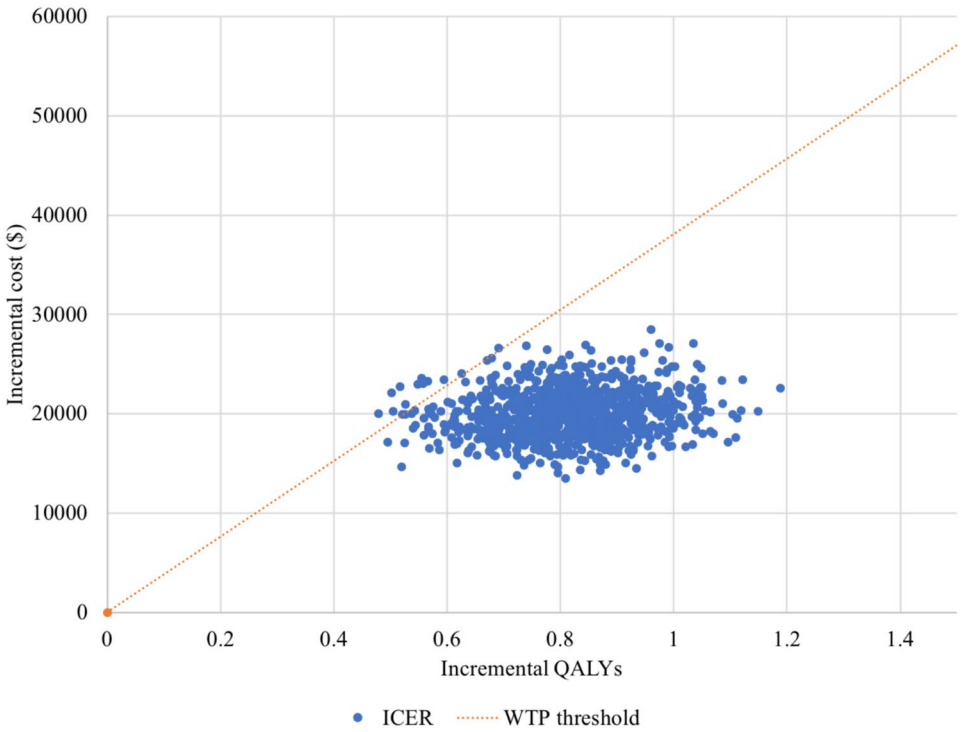

Fig. 3 ICER Scatterplot. *QALYs* quality-adjusted life-years, *WTP* willingness-to-pay, *ICER* incremental cost-effectiveness ratio, *GDP* gross domestic product

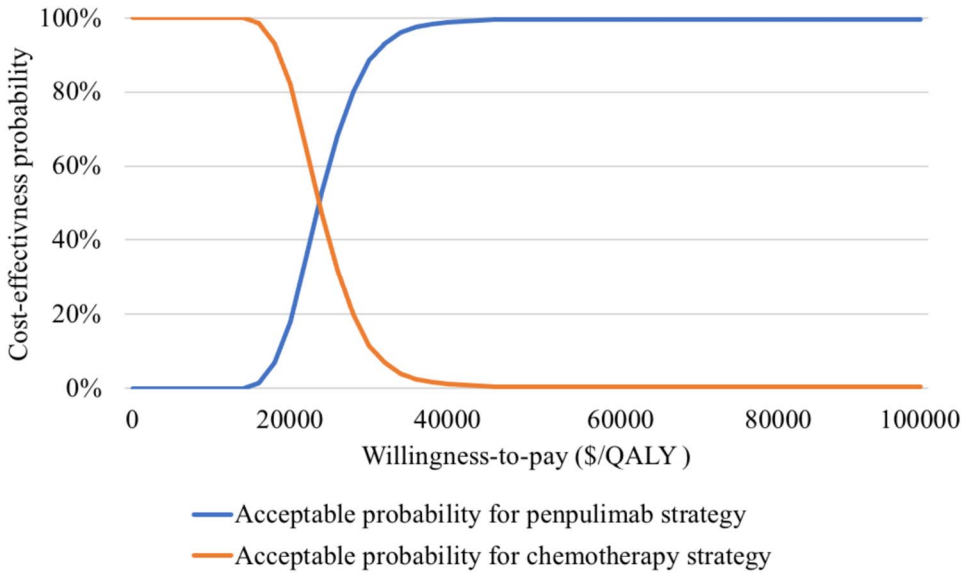

Fig. 4 Cost-effectiveness acceptability curves for penpulimab strategy and chemotherapy strategy. *QALYs* quality-adjusted life-years

$24,423 per QALY) compared with the base–case analysis. Table 3 presents the results of the scenario analysis.

Table 3 Results of Scenario Analysis

	Cost	LYs	QALYs	ICER
Penpulimab strategy	$27,165	3.089	1.763	$24,423/QALY
Chemotherapy strategy	$6855	1.913	0.932	

LYs life-years, *QALYs* quality-adjusted life-years, *ICER* incremental cost-effectiveness ratio

4 Discussion

The utilization of immune checkpoint inhibitors has significantly improved the outcomes of patients with advanced NSCLC who do not harbor gene mutations [61,62]. The Food and Drug Administration and the NMPA of China have approved several PD-1/PD-L1 inhibitors for first- or second-line immunotherapy in the treatment of advanced NSCLC [63,64]. Given the vital importance of controlling drug spending for healthcare system sustainability, cost-effectiveness evaluations become particularly crucial for immunotherapeutic agents in high-incidence malignancies such as lung cancer [65]. Our study revealed that, from the perspective of the Chinese healthcare system, penpulimab plus paclitaxel and carboplatin combination therapy resulted in an 0.821 incremental QALYs and $20,335 incremental costs, leading to an ICER of $24,778 per QALY compared with paclitaxel and carboplatin combination therapy. With a threshold of three times the per capita GDP, penpulimab plus paclitaxel and carboplatin combination therapy was found to be cost-effective.

Studies have shown variability in the cost-effectiveness of immunotherapies across different healthcare systems. Several studies have revealed that some approved immunotherapies are cost-effective in the European healthcare system [66]. Conversely, analyses within the Chinese healthcare system have indicated that some of these treatments may not be cost-effective, highlighting the influence of regional economic factors and healthcare policies on the value assessment of these therapies [67–69]. As immunotherapies contribute significant improvement in QALYs, further studies identifying factors contributing to the discrepancy in the cost-effectiveness should be conducted.

In addition, evaluating the cost-effectiveness of cancer drugs is imperative to address the rising medical expenditures and retain budget affordability. Owing to the substantial economic burden imposed by cancer treatment, China spent more than $30 billion on medical expenditures in 2015 [70]. The amount is anticipated to rise to $40.4 billion by 2025 [71]. This study assessed the cost-effectiveness of penpulimab plus paclitaxel and carboplatin combination therapy as a first-line treatment for locally advanced or metastatic sqNSCLC. Our study is based on clinical trial data entirely derived from the Chinese population, thereby providing high-level evidence of economic evaluation fit for Chinese clinical and healthcare practice.

Our findings indicated that penpulimab plus paclitaxel and carboplatin combination therapy showed better long-term clinical efficacy compared with paclitaxel and carboplatin combination therapy. Compared with other first-line immunotherapies recommended by clinical Chinese guidelines for the treatment of sqNSCLC, such as sugemalimab (median PFS of 4.1 months) [72] and sintilimab (median PFS of 5.5 months) [73], penpulimab had longer median PFS of 7.6 months. In estimating long-term clinical efficacy,

most cost-effectiveness analyses for sqNSCLC had been using only standard parameter distributions [67,69,74–77]. However, studies have shown that flexible parametric distributions of the PO and probit models generally predict 10-year survival rates more accurately than standard parameter distributions [22,78]. Therefore, we employed a more flexible parametric distribution, which is a restricted cubic spline to enhance the accuracy of capturing nuances in survival curve dynamics, thereby achieving better fitting long-term clinical efficacy outcomes. By visual inspection and comparison of the long-term extrapolated survival curves, it was found that the PFS extrapolation effect of penpulimab was also better than that of sugemalimab and sintilimab.

For patients with positive PD-L1 taking up to 51.8% of the entire sqNSCLC in China, we conducted a subgroup analysis focusing on patients with positive PD-L1 [79]. In treatment decision-making, the integration of PD-L1 levels is essential. Studies have indicated that the cost-effectiveness of medications could differ on the basis of PD-L1 expression levels [80]. Two economic evaluations conducted on Chinese patients with positive PD-L1 expression indicated that pembrolizumab and atezolizumab might not be cost-effective choices as first-line treatment for patients with positive PD-L1 expression in China [81,82]. Our study showed that penpulimab is cost-effective in patients with PD-L1 $\geq$ 1% as well as the base–case population, suggesting its potential as a novel therapeutic alternative for patients with positive PD-L1 expression.

In the one-way sensitivity analysis, the tornado diagrams emphasized the critical factors affecting the model outcomes, with a specific focus on the utility values of PFS state and the cost of penpulimab. In the cost-effectiveness studies of pembrolizumab, tislelizumab, and sugemalimab, the utility value of PFS was also identified as parameters exerting a significant influence on the ICER [68,69,74]. Our study selected the utility value observed in a Chinese population with NSCLC, which has been cited in multiple publications [67,75–77]. Although our one-way sensitivity analysis results show that the utility value of PFS has a significant impact on ICER, the confidence interval was consistently lower than WTP. The cost of penpulimab was another contributing factor. We observed in other literature that drug cost is commonly a most sensitive factor influencing the ICER in other literatures [67,83]. In recent years, the Chinese government has integrated several anticancer medications into the NRDL, resulting in price reductions ranging from 30 to 70% [67]. Conversely, penpulimab is not included in the NRDL, necessitating that patients bear the entire treatment cost, which could lead to a substantial medical burden. Given the cost-effectiveness of the penpulimab strategy demonstrated in this study, we suggest an active movement toward the listing of penpulimab in the NRDL. In addition, to enhance the affordability of medication for patients in need and to compensate for the cost of research and development, the Chinese government should consider value-based pricing policies such as risk-sharing agreements [84].

This study had some limitations. First, at the time of data cutoff in the AK105-302 trial, the OS curves for penpulimab plus paclitaxel and carboplatin combination therapy were not mature (the median OS was not achieved). In addition, a lack of survival data existed for patients in the positive PD-L1 subgroup. Thus, the OS was assumed to be consistent with the base–case population. Updating OS through long-term follow-up may strengthen this evidence in future studies. Second, for second-line treatment after disease progression, docetaxel was considered for both groups. While there may be several other second-line treatment options to take in practice, docetaxel monotherapy has been recommended for second-line therapy to patients who had immunotherapy or chemotherapy in the prior line of therapy according to clinical guideline [18]. Future studies incorporating real-world data should be conducted to better capture actual clinical practices. Third, this study exclusively focused on the Chinese data. The efficacy was drawn from a clinical trial involving Chinese participants, while the cost relies on Chinese data. The generalizability to other countries may be constrained, but we believe this study constitutes crucial evidence for decision-making in China. Moreover, the results may offer insights for researchers in various global settings. Despite these limitations, the cost-effectiveness analysis provides valuable information for future treatment and healthcare decisions.

5 Conclusions

For patients with locally advanced or metastatic sqNSCLC and those in the positive PD-L1 subgroup, ICERs were below three times the per capita GDP of China. Penpulimab plus paclitaxel and carboplatin combination therapy is anticipated to improve the life expectancy and quality of life of patients. From the perspective of the Chinese healthcare system, penpulimab plus paclitaxel and carboplatin combination therapy can be deemed a cost-effective choice compared with paclitaxel and carboplatin in patients with locally advanced or metastatic sqNSCLC. Our research underscores the need for policymakers in China to formulate pricing strategies that align drug prices with their intrinsic value. Additionally, we fill a gap in the current literature by providing new evidence for lung cancer treatment.

Supplementary Information The online version contains supplementary material available at https://doi.org/10.1007/s40261-025-01439-6.

Declarations

Funding Open Access funding enabled and organized by SungKyunKwan University. This study was funded by the China Scholarship Council (no. 202307060014). Funders had no role in the conceptualization, conduction, and manuscript preparation.

Conflict of Interest The authors declare to have no conflict of interest that could influence the work reported in this paper.

Ethics Approval This study is based on non-individual patient data, and did not include the use of human participants or animals. Therefore, ethical review and approval were not required for the study.

Consent to Participate Not applicable.

Consent for Publication Not applicable.

Code Availability Not applicable.

Data Availability The original research data included in this study are incorporated within the main article and Supplementary Material.

Author Contributions Meng Han: writing (original draft and review/editing), methodology, investigation, formal analysis, data curation, funding acquisition, and conceptualization. Hye-In Jung: writing (original draft and review/editing), methodology, investigation, formal analysis, data curation, and conceptualization. Yong-Fa Chen: supervision, resource management, project administration, funding acquisition, and conceptualization. Eui-Kyung Lee: writing (review/editing), supervision, project administration, methodology, funding acquisition, and conceptualization. All authors approved the final manuscript version.

References

1. Sung H, Ferlay J, Siegel RL, et al. Global cancer statistics 2020: GLOBOCAN estimates of incidence and mortality worldwide for 36 cancers in 185 countries. CA Cancer J Clin. 2021;71:209–49. https://doi.org/10.3322/caac.21660.
2. Siegel RL, Miller KD, Jemal A. Cancer statistics, 2020. CA Cancer J Clin. 2020;70:7–30. https://doi.org/10.3322/caac.21590.
3. Wu Y, Jiang Y, Wang W, et al. Estimating the long-term survival of unresectable stage III non-small cell lung cancer based on cure model analysis. Radiother Oncol. 2024;197:110341. https://doi.org/10.1016/j.radonc.2024.110341.
4. Gao M, Zhou Q, The Second School of Clinical Medicine, et al. Progress in treatment of advanced squamous cell lung cancer. Chin J Lung Cancer. 2020;23:866–74.
5. Rui M, Fei Z, Wang Y, et al. Cost-effectiveness analysis of sintilimab + chemotherapy versus camrelizumab + chemotherapy for the treatment of first-line locally advanced or metastatic nonsquamous NSCLC in China. J Med Econ. 2022;25:618–29. https://doi.org/10.1080/13696998.2022.2071066.
6. Oncology TCSoC. Guidelines of Chinese Society of Clinical Oncology Non-Small Cell Lung Cancer. 2023. Beijing.
7. Durbin L, Murali B, Li S, et al. Treatment patterns in non-small-cell lung cancer in China: Results from the CancerMPact survey 2020. Cancer Treat Res Commun. 2021;29:100462. https://doi.org/10.1016/j.ctarc.2021.100462.
8. Huang Z, Pang X, Zhong T, et al. Penpulimab, an Fc-engineered IgG1 anti-PD-1 antibody, with improved efficacy and low incidence of immune-related adverse events. Front Immunol. 2022;13:924542. https://doi.org/10.3389/fimmu.2022.924542.
9. Zheng Y, Fang YC, Li J. PD-L1 expression levels on tumor cells affect their immunosuppressive activity. Oncol Lett. 2019;18:5399–407. https://doi.org/10.3892/ol.2019.10903.
10. Zhong H, Sun S, Chen J, et al. First-line penpulimab combined with paclitaxel and carboplatin for metastatic squamous non-small-cell lung cancer in China (AK105-302): a multicentre, randomised, double-blind, placebo-controlled phase 3 clinical trial. Lancet Respir Med. 2024;12:355–65. https://doi.org/10.1016/S2213-2600(23)00431-9.
11. Chen Z, Hu T, Zhou J, et al. Overview of tumor immunotherapy based on approved drugs. Life Sci. 2024;340:122419. https://doi.org/10.1016/j.lfs.2024.122419.
12. Yue X, Li Y, Wu J, et al. Current development and practice of pharmacoeconomic evaluation guidelines for universal health coverage in China. Value Health Reg Issues. 2021;24:1–5. https://doi.org/10.1016/j.vhri.2020.07.580.
13. Durbin L, Murali B, Li S, et al. Treatment patterns in advanced/metastatic non-small-cell lung cancer in China: results from the CancerMPact® survey 2021. Future Oncol. https://doi.org/10.1016/j.ctarc.2021.100462.
14. Liu G, Hu S, Wu J, et al. China guidelines for pharmacoeconomic evaluations (Chinese-English version). Beijing: China Market Press; 2020.
15. Center for Drug Evaluation N. Marketed drug information: penpulimab. NMPA. 2023. https://www.cde.org.cn/main/xxgk/listpage/b40868b5e21c038a6aa8b4319d21b07d. Accessed July 17 2024.
16. Center for Drug Evaluation N. Marketed drug information: paclitaxel. NMPA. 2022. https://www.cde.org.cn/main/xxgk/postmarketpage?acceptidCODE=56578f3ea30462748a948ad5ddfa1cdf. Accessed July 17 2024.
17. Center for Drug Evaluation N. Marketed drug information: carboplatin. NMPA. 2019. https://www.cde.org.cn/main/xxgk/listpage/b40868b5e21c038a6aa8b4319d21b07d. Accessed July 17 2024.
18. Oncology TCSoC. Chinese Medical Association guideline for clinical diagnosis and treatment of lung cancer (2023 edition). Chin J Oncol. 2023;45:539–74.
19. Oncology ECoN-sCLCotCSoC. Chinese expert consensus on second-line treatment for non-small cell lung cancer with negative driver gene mutations. Chin J Lung Cancer. 2024;27:81–7.
20. Davies J, Patel M, Gridelli C, et al. Real-world treatment patterns for patients receiving second-line and third-line treatment for advanced non-small cell lung cancer: a systematic review of recently published studies. PLoS ONE. 2017;12:e0175679. https://doi.org/10.1371/journal.pone.0175679.

21. Guyot P, Ades A, Ouwens MJ, et al. Enhanced secondary analysis of survival data: reconstructing the data from published Kaplan-Meier survival curves. BMC Med Res Methodol. 2012;12:1–13. https://doi.org/10.1186/1471-2288-12-9.
22. Palmer S, Borget I, Friede T, et al. A guide to selecting flexible survival models to inform economic evaluations of cancer immunotherapies. Value Health. 2023;26:185–92. https://doi.org/10.1016/j.jval.2022.07.009.
23. Rulli E, Ghilotti F, Biagioli E, et al. Assessment of proportional hazard assumption in aggregate data: a systematic review on statistical methodology in clinical trials using time-to-event endpoint. Br J Cancer. 2018;119:1456–63. https://doi.org/10.1038/s41416-018-0302-8.
24. Deo SV, Deo V, Sundaram V. Survival analysis-part 2: Cox proportional hazards model. Indian J Thorac Cardiovasc Surg. 2021;37:229–33. https://doi.org/10.1007/s12055-020-01108-7.
25. Cooper M, Smith S, Williams T, et al. How accurate are the longer-term projections of overall survival for cancer immunotherapy for standard versus more flexible parametric extrapolation methods? J Med Econ. 2022;25:260–73. https://doi.org/10.1080/13696998.2022.2030599.
26. Quinn C, Garrison LP, Pownell AK, et al. Current challenges for assessing the long-term clinical benefit of cancer immunotherapy: a multi-stakeholder perspective. J ImmunoTherapy of Cancer. 2020;8(2):e000648. https://doi.org/10.1136/jitc-2020-000648
27. Stein-O'Brien G, Kagohara LT, Li S, et al. Integrated time course omics analysis distinguishes immediate therapeutic response from acquired resistance. Genome Med. 2018;10:37. https://doi.org/10.1101/136564.
28. Royston P, Parmar MK. Flexible parametric proportional-hazards and proportional-odds models for censored survival data, with application to prognostic modelling and estimation of treatment effects. Stat Med. 2002;21:2175–97. https://doi.org/10.1002/sim.1203.
29. Ng R, Kornas K, Sutradhar R, et al. The current application of the Royston-Parmar model for prognostic modeling in health research: a scoping review. Diagn Progn Res. 2018;2:4. https://doi.org/10.1186/s41512-018-0026-5.
30. Exchange SAoF. Exchange Rate. *Exchange Rate*. State administration of foreign exchange. 2024. www.safe.gov.cn. Accessed May 12, 2024.
31. Net Y. Drugdataexpy: marketing information, local bid-wining price, (2024, accessed May 12 2024).
32. Chinese drug price of drug centralized bid procurement. Menet Net. 2024. www.menet.com.cn. Accessed May 12, 2024.
33. GC. Calculation of creatinine clearance in clinical pharmacokinetic studies. Chin Pharm J. 1982;(04):44–45.
34. Calvert AH, Newell DR, Gumbrell LA, et al. Carboplatin dosage: prospective evaluation of a simple formula based on renal function. J Clin Oncol. 1989;7:1748–56. https://doi.org/10.1200/JCO.1989.7.11.1748.
35. Prevention CCfDCa. Report on the Nutrition and Chronic Diseases Status of Chinese Residents. Report no. 0512-7955, 2020. Beijing.
36. Summary list of medical service pricing items for provincial-level public hospitals in Zhejiang Province. In: Bureau ZPHS, editor. http://ybj.zj.gov.cn/art/2025/1/8/art_1229225636_5440756.html2024. Accessed May 20, 2024.
37. Medical service price inquiry. In: Bureau BMMS, editor. https://zyk.bjhd.gov.cn/sjkf/wsyl/202210/t20221028_4560548.shtml2022. Accessed May 20, 2024.
38. Shaanxi province medical service project prices (2021 Edition). In: Bureau SPMS, editor. https://ybj.shaanxi.gov.cn/gk/zcwj/15106.htm2021. Accessed May 20, 2024.
39. Summary table of medical service prices in Shanghai (2024 Edition). In: Bureau SMMS, editor. https://ybj.sh.gov.cn/cmsres/9b/9baabfec6f6c4e3fa03d6289f5e7781e/4370282a95455a99d4a3df42127e5ded.pdf2024. Accessed May 20, 2024.
40. Tianjin medical service price inquiry system. http://www.tjcp2017.com/index.php?w=web: Tianjin Medical Security Bureau. Accessed May 20, 2024.
41. Price compilation of medical service items in Sichuan provincial public medical institutions (2023). In: Province HCSAoS, editor. https://m12333.cn/policy/muusy.html2023. Accessed May 20, 2024.
42. Medical service price inquiry system (2024 version). http://ybj.shandong.gov.cn/col/col97806/index.html: Health care security administration of Shandong Province, 2024. Accessed May 20, 2024.
43. Jiangsu medical service price list (2023 edition). In: Province HCSAoJ, editor. https://ybj.jiangsu.gov.cn/art/2024/4/16/art_73935_11219533.html2023. Accessed May 20, 2024.
44. Guangdong basic medical service price list (2021 edition). In: Province HCSAoG, editor. http://hsa.gd.gov.cn/gkmlpt/content/3/3262/post_3262767.html#4452021. Accessed May 20, 2024.
45. Hunan provincial medical service price list (2024 edition). In: Province HCSAoH, editor. http://ybj.hunan.gov.cn/ybj/first113541/firstF/f2113606/202404/33291173/files/0c108c39aa154b6aa6779543b8c61a5a.pdf2024. Accessed May 20, 2024.
46. Hubei medical service price items and medical insurance payment directory (2023 version). In: Province HCSAoH, editor. https://ybj.hubei.gov.cn/zfxxgk/zc/qtzdgkwj/202404/t20240407_5150505.shtml2023. Accessed May 20, 2024.
47. Anhui medical service price item directory (2022 edition). In: Province HCSAoA, editor. https://ybj.ah.gov.cn/public/7071/146806461.html2022. Accessed May 20, 2024.
48. Henan Province medical service price item standardized price list. In: Province HCSAoH, editor. http://www.hnszsy.cn/uploads/file/20231030/1698634245469853.pdf2023. Accessed May 20, 2024.
49. Hebei city public hospital medical service price inquiry form. In: Administration HPHS, editor. http://ylbzj.hebei.gov.cn/cms/content/33512024. Accessed May 20, 2024.
50. List of medical service price items in Jilin Province (2024 edition). In: Administration JPHS, editor. http://ybj.jl.gov.cn/fwgk/ybml/ylfwjg/202003/P020240422327991201792.pdf2024. Accessed May 20, 2024.
51. Gong J, Su D, Shang J, et al. Cost-effectiveness of tislelizumab versus docetaxel for previously treated advanced non-small-cell lung cancer in China. Front Pharmacol. 2022;13:830380. https://doi.org/10.3389/fphar.2022.830380.
52. Zhou Q, Shun Lu, Li Y, et al. Chinese expert consensus on management of special adverse effects associated with lorlatinib. Chin J Lung Cancer. 2022;25:555–66.
53. Committee CSoCOGW. Chinese Society of Clinical Oncology (CSCO) Immune Checkpoint Inhibitor-related Toxicity Management Guidelines 2019. Beijing.
54. Li Z, Pan Z, Zhang L, et al. End-of-life cost and its determinants for cancer patients in urban China: a population-based retrospective study. BMJ Open. 2019;9:e026309. https://doi.org/10.1136/bmjopen-2018-026309.
55. Nafees B, Lloyd AJ, Dewilde S, et al. Health state utilities in non-small cell lung cancer: An international study. Asia-Pac J Clin Oncol. 2017;13:e195–203. https://doi.org/10.1111/ajco.12477.
56. Patel RR, Albert TJ, Rihn JA. Cost-effectiveness, QALYs, and incremental cost-effectiveness ratios. Semin Spine Surg. 2014;26:2–7. https://doi.org/10.1053/j.semss.2013.07.003.
57. China NBoSo. National Bureau of Statistics of China (NBS): National Data. National Bureau of Statistics of China. 2024. https://data.stats.gov.cn/english/easyquery.htm?cn=C01. Accessed April 10 2024.

58. Bongers ML, Coupé VM, Jansma EP, et al. Cost effectiveness of treatment with new agents in advanced non-small-cell lung cancer: a systematic review. Pharmacoeconomics. 2012;30:17–34. https://doi.org/10.2165/11595000-000000000-00000.
59. Edlin R, McCabe C, Hulme C, et al. Probability distributions for cost and utility parameters. In: Edlin R, McCabe C, Hulme C, Hall P, Wright J, editors. Cost effectiveness modelling for health technology assessment: a practical course. Cham: Springer International Publishing, 2015, pp.105–118.
60. Sculpher MJ, Basu A, Kuntz KM, et al. 289Reflecting Uncertainty in cost-effectiveness analysis. In: Neumann PJ, Ganiats TG, Russell LB, et al., editors. Cost-effectiveness in health and medicine. Oxford University Press; 2016.
61. Chen R, Manochakian R, James L, et al. Emerging therapeutic agents for advanced non-small cell lung cancer. J Hematol Oncol. 2020;13:58. https://doi.org/10.1186/s13045-020-00881-7.
62. Nadal E, Massuti B, Dómine M, et al. Immunotherapy with checkpoint inhibitors in non-small cell lung cancer: insights from long-term survivors. Cancer Immunol Immunother. 2019;68:341–52. https://doi.org/10.1007/s00262-019-02310-2.
63. Xin-yi C, Cheng-cheng Z, Qing Xi, et al. A rapid health technology assessment of sintilimab combined with chemotherapy for locally advanced or metastatic non-small cell lung cancer. Clin Med J. 2023;21:69–74.
64. Twomey JD, Zhang B. Cancer Immunotherapy Update: FDA-approved checkpoint inhibitors and companion diagnostics. AAPS J. 2021;23:39. https://doi.org/10.1208/s12248-021-00574-0.
65. Giuliani J, Bonetti A. Immunotherapy in first-line for advanced non-small cell lung cancer: a cost-effective choice? Recenti Progessi in Medicina. 2019;110:138–43. https://doi.org/10.1701/3132.31141.
66. Giuliani J, Bonetti A. Nivolumab in second-line treatment for advanced non-small-cell lung cancer with squamous-cell histology: a perspective based on pharmacologic costs. Clin Lung Cancer. 2017;18:e363–5. https://doi.org/10.1016/j.cllc.2017.04.007.
67. Liu Q, Luo X, Peng L, et al. Nivolumab versus docetaxel for previously treated advanced non-small cell lung cancer in China: a cost-effectiveness analysis. Clin Drug Investig. 2020;40:129–37. https://doi.org/10.1007/s40261-019-00869-3.
68. Liao W, Huang J, Hutton D, et al. Cost-effectiveness analysis of first-line pembrolizumab treatment for PD-L1 positive, non-small cell lung cancer in China. J Med Econ. 2019;22:344–9. https://doi.org/10.1080/13696998.2019.1570221.
69. Li W, Wan L. Cost-effectiveness analysis of sugemalimab vs. placebo, in combination with chemotherapy, for treatment of first-line metastatic NSCLC in China. Front Public Health. 2022;10:1015702. https://doi.org/10.3389/fpubh.2022.1015702.
70. Zheng RS, Sun KX, Zhang SW, et al. Report of cancer epidemiology in China, 2015. Zhonghua Zhong Liu Za Zhi. 2019;41:19–28.
71. Liu C, Shi J, Wang H, et al. Population-level economic burden of lung cancer in China: Provisional prevalence-based estimations, 2017–2030. Chin J Cancer Res. 2021;33:79–92.
72. Zhou C, Wang Z, Sun Y, et al. Sugemalimab versus placebo, in combination with platinum-based chemotherapy, as first-line treatment of metastatic non-small-cell lung cancer (GEMSTONE-302): interim and final analyses of a double-blind, randomised, phase 3 clinical trial. Lancet Oncol. 2022;23:220–33.
73. Zhou C, Wu L, Fan Y, et al. Sintilimab plus platinum and gemcitabine as first-line treatment for advanced or metastatic squamous NSCLC: results from a randomized, double-blind, phase 3 trial (ORIENT-12). J Thorac Oncol. 2021;16:1501–11. https://doi.org/10.1016/j.jtho.2021.04.011.
74. Gong J, Su D, Shang J, et al. Cost-effectiveness of tislelizumab versus docetaxel for previously treated advanced non-small-cell lung cancer in China. Front Pharmacol. 2022. https://doi.org/10.3389/fphar.2022.830380.
75. Liang X, Chen X, Li H, et al. Cost-effectiveness of camrelizumab plus chemotherapy in advanced squamous non-small-cell lung cancer. Immunotherapy. 2023;15:1133–42. https://doi.org/10.2217/imt-2023-0008.
76. Wang H, Zeng C, Li X, et al. Cost-utility of afatinib and gefitinib as first-line treatment for EGFR-mutated advanced non-small-cell lung cancer. Future Oncol. 2018;15:181–91.
77. Yang Z, Zhu Y, Xiang G, et al. First-line atezolizumab plus chemotherapy in advanced non-squamous non-small cell lung cancer: a cost-effectiveness analysis from China. Expert Rev Pharmacoecon Outcomes Res. 2021;21:1061–7.
78. Gray J, Sullivan T, Latimer NR, et al. Extrapolation of survival curves using standard parametric models and flexible parametric spline models: comparisons in large registry cohorts with advanced cancer. Med Decis Making. 2021;41:179–93. https://doi.org/10.1177/0272989X20978958.
79. Yang X, Jiang L, Jin Y, et al. PD-L1 Expression in Chinese patients with advanced non-small cell lung cancer (NSCLC): a multi-center retrospective observational study. J Cancer. 2021;12:7390–8. https://doi.org/10.7150/jca.63003.
80. Yang SC, Ou HT, Su WC, et al. Cost-effectiveness of first-line immunotherapies for advanced non-small cell lung cancer. Cancer Med. 2023;12:8838–50. https://doi.org/10.1002/cam4.5632.
81. Zhou K, Jiang C, Li Q. Cost-effectiveness analysis of pembrolizumab monotherapy and chemotherapy in the non-small-cell lung cancer with different PD-L1 tumor proportion scores. Lung Cancer. 2019;136:98–101. https://doi.org/10.1016/j.lungcan.2019.08.028.
82. Liu G, Kang S, Wang X, et al. Cost-effectiveness analysis of atezolizumab versus chemotherapy as first-line treatment for metastatic non-small-cell lung cancer with different PD-L1 expression status. Front Oncol. 2021. https://doi.org/10.3389/fonc.2021.669195.
83. Liu X, Liu X-X, Shao W, et al. Cost-effectiveness analysis of camrelizumab plus paclitaxel and carboplatin versus sintilimab plus gemcitabine and cisplatin or carboplatin for the first-line treatment of local advanced or metastatic squamous NSCLC in Chinese mainland. Front Pharmacol. 2024. https://doi.org/10.3389/fphar.2024.1356725.
84. Gonçalves FR, Santos S, Silva C, et al. Risk-sharing agreements, present and future. Ecancermedicalscience. 2018;12:823. https://doi.org/10.3332/ecancer.2018.823.