A systematic review of the budget impact analyses for antitumor drugs of lung cancer

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Abstract

Background: Budget impact analyses (BIAs) are used for reimbursement decisions and drug access medical insurance, as a supplement to cost-effectiveness analyses (CEAs).

Objectives: We systematically reviewed BIAs for antitumor drugs of lung cancer to provide reference for high-value drug budget impact analyses and decision making.

Methods: We conducted a literature search on PubMed, EMBase, The Cochrane Library, China National Knowledge Infrastructure and Wanfang Data Knowledge Service Platform from 2010 to 2019. The methodological indicators and result information of the budget impact analyses were extracted and evaluated for quality.

Results: A total of 14 studies on the budget impact for antitumor drugs of lung cancer were included, and the overall quality was good. Half of studies were from developed countries. Nine of the studies were designed using the BIA cost calculation model, and two were simulated using the Markov model Monte Carlo model. From all studies, only 14.3% reported model validation. The budget impact results of the same drug in different countries were inconsistent.

Conclusions: Included studies evaluating budget impact analyses for anti-tumor drugs of lung cancer showed variability in the methodological framework for BIAs. The budget impact analyses of high-value drugs need to be more stringent to ensure the accuracy of the parameters, and should provide reliable results based on real data to decision-making departments, which should carefully consider access to lung cancer drugs.

Keywords: Budget impact analyses, Antitumor drugs, Lung cancer

Background

Lung cancer is the most frequent cancer and the leading cause of cancer death among males. According to the Global cancer statistics 2018, lung cancer is the most common diagnosed cancer accounting for 11.6% of the total cases, and the leading cause of cancer death accounting for 18.4% of the total cancer deaths worldwide. In 2018, there were estimated to be 2.1 million new lung cancer cases and 1.8 million deaths [1]. Meanwhile, lung cancer had the highest economic cost with €18.8 billion, 15% of overall cancer costs in the European Union [2].

The World Health Organization (WHO) divides lung cancer into non-small cell lung cancer (NSCLC) and small cell lung cancer (SCLC) based on its biology, therapy, and prognosis [3, 4]. NSCLC includes two major types that account for more than 80% of total lung cancer cases: non-squamous cell, including adenocarcinoma, large cell carcinoma, and other cell types; and squamous cell (epidermoid) carcinoma [5]. In patients with NSCLC, the most commonly found Epidermal Growth Factor Receptor (EGFR) mutations are deletions in exon 19 and a mutation in exon 21 [6]. Both mutations result in activation of the tyrosine kinase domain, and both are associated with sensitivity to the small molecule tyrosine kinase inhibitors (TKIs), such as erlotinib, gefitinib, and afatinib.
EGFR mutations, but its safety is slightly lower than erlotinib. For patients with metastatic nonsquamous NSCLC who have sensitizing EGFR mutations, afatinib is also an oral TKI that inhibits the entire ErbB/HER family of receptors, including EGFR and HER2. The FDA has approved afatinib for first-line treatment of patients with metastatic nonsquamous NSCLC who have sensitizing EGFR mutations, but its safety is slightly lower than erlotinib or gefitinib.

ImmunocHECKPOINT inhibitors are preferred agents recommended for subsequent treatment by NCCN. For NSCLC patients without ALK rearrangement, ROS1 rearrangement, or sensitized EGFR mutations, immune checkpoint inhibitors (nivolumab, pembrolizumab, and atezolizumab) are the preferred choice for subsequent treatment of all histological subtypes because they have a higher survival rate, longer response duration and fewer adverse events compared to cytotoxic chemotherapy [6]. Pembrolizumab has been approved by the Food and Drug Administration (FDA) as subsequent therapy for patients with metastatic NSCLC whose disease has progressed after platinum-based chemotherapy if their tumors express PD-L1.

Since the high incidence of lung cancer and high treatment costs have a significant impact on drug availability and the continued operation of the reimbursement fund, it is important to study the cost budget for lung cancer drugs. Budget impact analysis (BIA) is designed to measure the combined impact of the inclusion of a new pharmaceutical product on health care spending. Its main aim should be to complete cost-effectiveness analyses (CEAs) for reimbursement and coverage particularly for short- and mid-term budget planning. The structure of BIA can be adjusted according to different needs for different countries as well as for time horizons, perspective and underlying diseases.

Many authorities have built up the BIA method by different criteria, but no one has provided a precise definition. Until 2007, the ISPOR Task Force presented guidance on methodologies for those reviewing the results of such analyses [20]. Then, the ISPOR Task Force developed good practice guidelines to improve high-quality BIAs [21]. At the same time, many countries and regions presented specific guidelines [22–24]. These guidelines report the analytical framework, key elements and reporting format for BIAs, including research perspective, budget time horizon, drugs and other cost, new interventions, uncertainty analysis and validation, etc.

However, as far as we know, there has been no review examining budget impact analysis studies in the field of lung cancer. Many developed countries use evidence-based health technology assessment (HTA) methods to conduct cost–benefit analysis of clinically selected medical technologies as one of the main content of drug reimbursement recommendations [25–27]. In recent years, expensive anti-tumor drugs have been included in the catalogue of basic medical insurance drugs of China [28, 29], and the related drug price negotiations have made significant progress, which has a greater impact on the accessibility of drugs to patients and the continued operation of the medical insurance fund. Therefore, we focus on the budget impact analysis of anti-tumor drugs used to treat lung cancer worldwide, aiming to summarize key elements, results, and assess the extent to which international BIA guidelines are followed in these studies.

**Methods**

We conducted a literature search of the databases PubMed, EMBASE and the Cochrance Library to select articles on budget impact analysis for antitumor Drugs of lung cancer published in English from 1 January 2010 until 31 October 2019. Similarly, we used keywords to search on CNKI and Wanfang Data Knowledge Service Platform of China. The following search strategy was used: (Budget impact* OR budget impact model OR budget impact analysis OR pharmacoeconomics*) AND (Antineoplastic Agents [MeSH Major Topic]). We included studies reporting budget impact models or budget impact methods of anti-tumor drugs based on randomized controlled trials, cross-sectional studies, cohort studies, model studies, etc. And excluded studies that only examined efficacy, toxicity, studies that conducted only cost-effectiveness analyses, reviews, comments, meeting abstracts and BIAs of other cancer patients. Two independent reviewers performed title and abstract screening and full-text selection. A third author resolved the disagreement.

Based on the ISPOR Task Force guidelines [5], we developed evidence tables presenting a summary of how each study addressed the key elements, such as population size and characteristics, budget holder’s perspective, budget time horizon, model structure, clinical and cost data, calculation, uncertainty analysis, etc. And then we systematically extracted data and summarized our findings from all included studies in evidence tables.
Meanwhile, the level of adherence to the ISPOR Task Force guidelines [5] was summarized for the following items: Budget holder’s perspective; target population estimate; 1–5 years of budget time horizon; hypothetical scenario; control group; analysis framework description; data collection and sources; model verification and sensitivity analysis. This review was conducted according to the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines [30]. The final included studies are all complete published literature, which may lead to inherent problems with publication bias.

Results

Figure 1 summarizes the search strategy and its results. 1490 articles were initially retrieved through the identified keywords on the budget impact analysis of antitumor drugs. After deduplication (n = 117), screening the title and abstract (n = 1228) and the full text of remaining studies (n = 131), 14 items were finally included BIA studies of antitumor drugs for lung cancer. Half of 14 studies were from Europe and America, among which six studies were conducted for the US population [31–36] and one for Norway [28]. In the other half, there are 3 studies from Thailand [21, 22, 26] and 3 studies from China [25, 37, 38] and 1 study from South American countries [29].

Table 1 summarizes general information for the 14 selected BIA studies [31–36, 39–46]. Thirteen articles were studied based on models [31–36, 39–43, 45, 46],

![PRISMA 2009 Flow Diagram](image)
and one article was studied based on population randomized controlled trials [44]. The eligible populations were mainly chosen according to the coverage of the payer’s plan [31–36, 39–46]. There were thirteen studies restricted the target population based on the type and degree of lung cancer [31–36, 40–46]. Half of the 14 articles were from developed countries, of which 6 were from the US [31–36], 1 was from Norway [43]; the remaining 3 were from Thailand [39, 40, 42], 3 were from China [41, 45, 46], and 1 was from developing countries in South America [44].

Table 2 summarizes the budget impact analysis method and research results of the reviewed studies. We refined the key elements such as application model, research perspective, budget time frame, treatment plan, direct cost, indirect cost, clinical and cost data sources, and sensitivity analysis methods. In 14 studies, 13 studies were conducted from the payer and the hospital, only one study was conducted from the perspective of private insurance companies [32]. Four studies considered a hypothetical population from the perspective of health commercial planning [31, 32, 35, 36], which were conducted for US populations. There were 13 studies that determined the research model, most of which used the BIA cost calculation model (also called cost decision model) [31–33, 35, 36, 39, 41, 42, 45, 46], and only two of which used the Markov model [40] and Monte Carlo model [34] to simulate the disease process.

The budget time horizon determined for the model is based on the requirements of the budget holder. The budget time horizon of the included studies was concentrated in 1–5 years, and there were 6 studies with shorter budget periods, only 1 year [31–34, 43, 44]. Most studies presented a budget time horizon of 3 years or more, 3 studies presented a budget time horizon of 3 years [35, 42, 46], 1 study presented a budget time horizon of 4 years [39]. Four studies presented a five-year budget time horizon [36, 40, 41, 45].

Treatment strategy in the reviewed studies were stated by 14 studies. Most studies compared research drug between A treatment strategy and B treatment strategy under different scenarios [31–33, 35, 39–43, 45, 46]. Two studies compared different doses of the same drug setting in the base case analysis [34, 36]. One study did not compare treatment strategies, but divided strategies according to different payment methods, including cost-sharing, risk-sharing, payment-by-results and discount [44].

Cost calculation in the reviewed studies was summarized as direct cost and condition-related cost. Direct cost included in the selection of cost accounting mainly take into account the cost of drugs and the cost of genetic testing. Adverse event cost and management costs are

| First author | Year | Country | Drugs | Research foundation | Population size, characteristics |
|--------------|------|---------|-------|---------------------|---------------------------------|
| Carlson [31] | 2011 | US      | Erlotinib | Model | 500,000 member US health plan; stage IIIb/IV NSCLC. |
| Farsai [39]  | 2011 | Thailand| Pemetrexed| Model | Lung cancer patients in the hospital |
| Sumitra [40] | 2012 | Thailand| Gefitinib | Model | 100,000 advanced NSCLC patients |
| Preeti [32]  | 2014 | US      | Erlotinib | Model | 500,000 member health plan; with advanced NSCLC |
| Lisa [33]    | 2016 | US      | Ramucirumab + docetaxel | Model | 150,000 patients in hospital; NSCLC Patients Receiving 2nd line Therapy |
| Mengyuan [41]| 2016 | China   | Gefitinib | Model | 74000 advanced NSCLC patients |
| Sumitra [42] | 2017 | Thailand| Crizotinib| Model | 5183 NSCLC in lung cancer patient; aged ≥19 years |
| Daniel [34]  | 2017 | US      | Pembrolizumab | Model | 19601 NSCLC patients with PD-L1 expression ≥ 50% |
| Jan [43]     | 2017 | Norway  | Pembrolizumab | Model | 3035 cases; Patients with advanced NSCLC 2nd line treatment |
| Pedro [44]   | 2018 | South American countries | Pembrolizumab | RCT | 3043 participants; patients with NSCLC for immunotherapy |
| Christopher [35]| 2018 | US      | Necitumumab | Model | 100,000 plan participants; msqNSCLC patients receiving first-line chemotherapy; aged ≥65 years |
| Jonathan [36]| 2018 | US      | Afatinib  | Model | Health plan for 1,000,000 people, metastatic NSCLC whose tumors have EGFR del19 or L858R mutations initiating first-line treatment; age ≥ 18 years |
| Xueyan [45]  | 2018 | China   | Icotinib | Model | 73,400 patients with advanced NSCLC who were genetically tested and eligible for icotinib in the insured population |
| Jie [46]     | 2019 | China   | Afatinib | Model | 45,554 patients with advanced NSCLC who were positive for EGFR mutation after chemotherapy in the insured population |

RCT Randomized controlled trial, NSCLC non-small cell lung cancer, msqNSCLC metastatic squamous non-small cell lung cancer
| First author | Model structure | Perspective | Budget time horizon | Treatment strategy | Cost calculation | Data sources | Sensitivity analysis | Research result |
|-------------|----------------|-------------|--------------------|--------------------|-----------------|-------------|-------------------|----------------|
| Carlson [31] | Cost calculator | Health plan | 1 year             | Erlotinib maintain- | Direct cost + con- | RCT, Medicare and | One-way          | Erlotinib PMPM increase |
|             |                |             |                    | ce maintenance      | dition-related cost | Medicaid and Drug |                  |                 |
|             |                |             |                    | VS Erlotinib mainte- |                | price database;  |                  |                 |
|             |                |             |                    | nance available     |                | published litera- |                  |                 |
| Farsai [39] | Cost calculator | Hospital    | 4 years            | Docetaxel VS Pem-    | Direct cost      | Hospital inpatient | One-way          | Annual budget of Pem- |
|             |                |             |                    | etrexed             |                | database         |                  | etrexed in hospital |
| Sumitra [40]| Markov model   | CSMBS       | 5 years            | Gefitinib, Erlotinib, | Direct cost + con- | RCT, NICE Public | One-way          | Cost saving of Gefitinib |
|             |                |             |                    | Pemetrexed, Doceta-  | dition-related cost | data            |                  |                 |
|             |                |             |                    | xel, Erlotinib       |                |                  |                  |                 |
|             |                |             |                    |                   |                |                  |                  |                 |
| Preeti [32] | Cost calculator | Private insurance company | 1 year | Erlotinib; Pac + Car; Bev + Pac + Car; Pem + Car | Direct cost | Hospital medical records; Medicare database | One-way | Erlotinib PMPM increase |
| Lisa [33] | Cost calculator | Hospital | 1 year | Ram + Doc; Bev + Erl; Docetaxel; Erlotinib; Pemetrexed | Direct cost | Public Data, Electronic medical record data | NR | After ramucirumab adding to hospital formulary annual margin increase |
| Mengyuan [41] | Cost calculator | Medical insurance | 5 years | Gefitinib VS chemotherapy | Direct cost | Tumor registration information; Project survey; Drug Market Trend Report | One-way | Budget savings after gefitinib is included in the medical insurance catalog |
| Sumitra [42] | Cost calculator | Payer | 3 years | Crizotinib VS no crizotinib | Direct cost + condition-related cost | Thailand official database; Hospital database | One-way | Crizotinib PMPM increase |
| Daniel [34] | Monte Carlo model | Payer | 1 year | Different dose control of the same drug | Direct cost | RCT/SEER and Medicare data | One-way | Budget savings for pembrolizumab of personalized dosing |
| Jan [43] | Cost minimization model | Payer | 1 year | Pembrolizumab VS Docetaxel or Pemetrexed | Direct cost + condition-related cost | RCT, National official data | One-way | Pembrolizumab 2nd-line treatment cost savings |
| Pedro [44] | NR | Payer | 1 year | Cost-sharing, risk-sharing, payment-by-results, discount | Direct cost | RCT, National official data | NR | Budget impact of pembrolizumab in the first-line decreased through risk-sharing |
| Christopher [35] | Cost calculator | U.S. commercial and Medicare health plans | 3 years | Before and after adoption of Neci + GCis | Direct cost + condition-related cost | RCT, U.S. prescription information and clinical guidelines; Public data | One-way | Neci + GCis annual budget increase |
| Jonathan [36] | Decision model | U.S. commercial health plan | 5 years | Constant Uptake VS Increase in Afatinib Uptake | Direct cost + condition-related cost | Public data; Project survey; Published literature | One-way | Afatinib annual budget increase |
### Table 2 (continued)

| First author | Model structure | Perspective | Budget time horizon | Treatment strategy | Cost calculation | Data sources | Sensitivity analysis | Research result |
|--------------|-----------------|--------------|---------------------|--------------------|------------------|--------------|---------------------|-----------------|
| Xueyan [45]  | Cost calculator | Medical insurance | 5 years | Icotinib VS chemotherapy | Direct cost | Published literature; Project survey data | One-way | Icotinib annual medical insurance cost budget savings |
| Jie [46]     | Cost calculator | Medical insurance | 3 years | With and without afatinib in the Chinese national reimbursement system | Direct cost | Published literature; Clinical expert opinion | One-way | Afatinib annual medical insurance budget expenditure decreases |

CSMBS Civil Servant Medical Benefit Scheme, Pac paclitaxel, Car carboplatin, Bev bevacizumab, Pem pemetrexed, Ram ramucirumab, Doc Docetaxel, Neci necitumumab, GCi gemcitabine and cisplatin, NR no report
called condition-related cost. Eight studies only calcu-
lated direct costs [32–34, 39, 41, 44–46], and six studies chose direct cost plus condition-related cost in cost calculation [31, 35, 36, 40, 42, 43]. The ISPOR Task Force guidelines [5] recommend that data should come from the best available sources and should be thoroughly quoted to support transparency and reproducibility. The 14 studies included in the study all clearly stated the source of clinical and cost data [31–36, 39–46], typically from surveys, official national data, published literature, and a few from randomized controlled trials.

Of the 14 reviewed studies, twelve studies were subjected to sensitivity analysis, and all methods were conducted using one-way sensitivity analysis [31, 32, 34–36, 39–43, 45, 46]. However, the selection of sensitivity analysis parameters is inconsistent, such as whether to analyze the treatment cycle. Regarding research on the budget impact analysis of drugs, the ISPOR Task Force guidelines did not recommend discounting [5], so we did not take into account discounting.

As for the result indicators, we found that the included studies were all presented in the form of budget amounts. Six studies indicated budget results increased [31, 32, 35, 36, 39, 42]. One of the studies explained that it was mainly due to the increase in the cost of drugs, that was, the increase in the cost of progression-free survival and treatment cycle extension [42]. The other study showed that the higher incremental budget in medical insurance was due to the higher incidence of metastatic squamous non-small cell lung cancer among elderly medical insurance patients [35]. On the contrary, six studies budget decreased [40, 41, 43–46]. One of the studies used the expected annual margin between costs and reimbursement to explain the results of budget impact analysis [33]. One study in the United States indicated that personalized-dosing of drug resulted in cost savings over fixed-dosing [34].

Table 3 provides a summary of the quality evaluation according to the ISPOR Task Force guidelines [5]. The consistency of the included BIAs and ISPOR Task Force guidelines indicates that the overall quality of the included studies was good, and 9 of included studies followed at least 8 of the guidelines (≥ 88.9%) [32–36, 40, 41, 43, 45], 4 studies [31, 39, 42, 46] followed 7 items (77.8%) in the guidelines. Only 1 study [44] followed less than 5 items (44.4%). Overall, most studies did not report model validation, and only 14.3% of the studies conducted model validation.

Discussion
We systematically reviewed the budget impact analysis for anti-tumor drugs of lung cancer, which from Europe, America, Asia and South America, covering a wide range of areas. And summarized methodological elements and research results to provide reference for the budget impact analysis of high-value drugs. Firstly, we found from these reviews of the design of published budget-impact models was that, despite published guidelines for budget-impact analysis, there were still significant differences in the included studies. Many countries and regions had issued budget impact analysis guidelines, such as Canada [6], France [7], and Ireland [8]. The latest China Guidelines for Pharmacoeconomic Evaluations was published in 2019, which included budget impact analysis methods and rules [47]. The BIA method has not been specified in a unified and standardized form, so there were significant differences between BIA studies.

Vooren [48] considered that BIA was not a mature technology in the literature in 2013, and many published studies have not yet reached acceptable quality. In particular, the short-term budget savings of high-value drugs might be caused by the bias of pharmaceutical companies. Mauskopf [37] found that many budget impact analyses’ designs were still different even for those analyses performed for a new drug for the same type of disease. Beate Jahn [38] also considered that best-practice guidelines were necessary to ensure high-quality analyses. Although we agreed on the importance of a mature framework for BIA, it was more important to implement the operations of BIA. Such as pembrolizumab, two studies in Norway [43] and south America [44] showed that pembrolizumab’s budget decreased, while Thailand’s [39] BIA study recognized that budget of pembrolizumab increased significantly. Erlotinib’s budget impact analysis results were consistent. Coincidentally, both of these two BIAs of erlotinib were from the United States. The consistent result may be related not only to the uniform BIA guidelines in the U.S., but also to the drug reimbursement policy in the U.S.. We also observed the results of BIAs showing a continuous decline in the health insurance budget for different drugs in China consistently [41, 45, 46]. We thought it was not only related to China’s special medical insurance drug policy, but also related to the input of related parameters of the BIA model. Therefore, we suggested that BIA research should carefully consider the size of the population based on real-world data, rather than model simulation, to make the budget impact results more realistic in order to provide a realistic reference for decision-making by decision-making departments.

From the Thai payer perspective, gefitinib was a dominant cost saving strategy compared with docetaxel for the second-line treatment of advanced NSCLC [40]. Since gefitinib had been reapproved through the FDA’s Phase IV study, it was now more accepted and very well tolerated by most patients [6]. New drugs such as
gefitinib should be paid more attention to comparing budget impact analysis of different drugs to ensure that there was no financial burden on the use of new drugs. Our review suggested that reasonable comparators should be set up based on the clinical pathway, and this kind of research had greater clinical reference value.

Meanwhile, the short-term increase or decrease in the budget impact results should not directly determine the inclusion or exclusion of drugs in the medical insurance catalog. On the contrary, the long-term budget impact of drugs should be considered. For instance, the impact of new drugs with good effects on the short-term budget has increased, but in the long run, they will save costs, can still be considered within the control of the medical insurance fund, and vice versa. Although the results of budget impact analysis of icotinib showed a downward trend, the extent of decline had decreased year by year [45]. Through the long-term budget time horizon research, the trend of budget increase or decrease could be seen to predict whether the fund was affordable.

We found that most of the included studies did not undergo model validation. Only two studies stated that the validity of the BIA model was discussed with clinical experts and relevant researchers [33, 43]. ISPOR had already put forward requirements for the validity verification of the BIA model in 2014 [5], and the latest economic evaluation guidelines in China had also made requirements for the validation of the BIA model, including face validation, technical validation and external validation [47]. Obviously, model validation should be a key element to ensure the accuracy of BIA research.

Then, we identified the following key elements for the design of the budget impact model: the BIA budget time horizon should be considered for at least the next 3-5 years; Considering the differences in previous BIAs, our review suggested that reasonable comparators should be set up based on real-world policy and the clinical pathway; Sensitivity analysis could consider the use of multi-factor analysis, which was sufficient to consider the correlation between various factors; Model validation and sensitivity analysis should be carried out to ensure the effectiveness of BIA research [49]; And the key elements should cooperate with each other to ensure effective budget impact analysis.

Compared with previous BIA reviews [37, 38, 48], this systematic review has been focuses on lung cancer drugs specifically. We have summarized the key elements to ensure the quality of BIA research comprehensively. In addition, we concluded the budget results of the included studies to provide a comprehensive reference for BIA studies of high-value drugs of lung cancer. Our systematic review has several limitations. First, some studies may have been missed because they were indexed in other databases or were published by conference did not appear in the journal publications retrieved by this study. Second, due to the language limitation, our systematic review included studies published in English and Chinese. References were retrieved from three

### Table 3 Quality evaluation of BIAs

| First author  | Perspective | Target population estimate | 1–5 years of budget time horizon | Hypothetical scenario | Comparator Frame description | Data collection and sources | Validation | Sensitivity analysis |
|---------------|-------------|-----------------------------|---------------------------------|-----------------------|-----------------------------|-----------------------------|------------|--------------------|
| Carlson [31]  | √           | √                           | √                               | √                     | √                           | √                           | √          | √                  |
| Farsai [39]   | √           | √                           | √                               | √                     | √                           | √                           | √          | √                  |
| Sumitra [40]  | √           | √                           | √                               | √                     | √                           | √                           | √          | √                  |
| Preeti [32]   | √           | √                           | √                               | √                     | √                           | √                           | √          | √                  |
| Lisa [33]     | √           | √                           | √                               | √                     | √                           | √                           | √          | √                  |
| Mengyuan [41] | √           | √                           | √                               | √                     | √                           | √                           | √          | √                  |
| Sumitra [42]  | √           | √                           | √                               | √                     | √                           | √                           | √          | √                  |
| Daniel [34]   | √           | √                           | √                               | √                     | √                           | √                           | √          | √                  |
| Jan [43]      | √           | √                           | √                               | √                     | √                           | √                           | √          | √                  |
| Pedro [44]    | √           | √                           | √                               | √                     | √                           | √                           | √          | √                  |
| Christopher   | √           | √                           | √                               | √                     | √                           | √                           | √          | √                  |
| Jonathan [36] | √           | √                           | √                               | √                     | √                           | √                           | √          | √                  |
| Xueyan [45]   | √           | √                           | √                               | √                     | √                           | √                           | √          | √                  |
| Jie [46]      | √           | √                           | √                               | √                     | √                           | √                           | √          | √                  |
international databases and two Chinese databases (PubMed, EMBASE, the Cochrance Library, CNKI and Wanfang Data Knowledge Service Platform of China). Third, the search time was limited to 2010-2019. Due to the variety of anti-tumor drug studies, the search time could not be exhausted, so we chose to search the relevant studies in the past decade. Fourth, in the summary of the results, the results were evaluated only from the vertical perspective of increase and decrease, and the budget results were not uniformly converted into international currency forms such as US dollars [50], so that there was no lateral difference evaluation of the extrapolation of results.

Conclusion
Although most of the included BIA studies are conducted from the perspective of payers, they have different methodological framework for recommended chemotherapy, targeted therapy, and immunotherapy agents for the treatment of lung cancer. For the same drugs, the results of budgetary effects are not consistent in different country. The budget impact analysis of high-value drugs such as anti-tumor drugs should be conducted more objectively, and the accuracy of parameters needs to be more strictly guaranteed. The high-quality BIAs should be based on real-world data to provide reliable results for decision-making departments. Furthermore, it is more worthy of attention that the budgetary impact of the same drug is not always consistent over time, so access to drugs should be measured in the long run.

Supplementary Information
The online version contains supplementary material available at https://doi.org/10.1186/s12962-020-00253-5.

Additional file 1: Table S1. PRISMA 2009 checklist.

Abbreviations
BIAs: Budget impact analyses; CEAs: Cost-effectiveness analyses; NSCLC: Non-small cell lung cancer; SCLC: Small cell lung cancer; EGFR: Epidermal Growth Factor Receptor; TKIs: Tyrosine kinase inhibitors; ALK: Anaplastic lymphoma kinase; CNKI: China national knowledge infrastructure.

Acknowledgements
Not applicable.

Authors’ contributions
Conceptualization: LH, GXL, XZ. Methodology: LH, GXL, XZ. Literature search: LH, WQF, CYW, XMZ, LRZ. Formal analysis and investigation: LH, WQF, CYW, XMZ, LRZ. Writing—original draft: LH. Writing—review and editing: XZ. Supervision: GXL, XZ. All authors read and approved the final manuscript.

Funding
This study was funded by National Key research and development plan of China (2017YFC1308700, 2017YFC1308705). The funding body did not have any influence on the design of the study and collection, analysis, and interpretation of data and in manuscript writing.

Availability of data and materials
All data involved in this study are included in this published article and its supplementary information files.

Ethics approval and consent to participate
Not applicable.

Consent for publication
Not applicable.

Competing interests
None of the authors have any competing interests.

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Received: 13 October 2020 Accepted: 24 November 2020
Published online: 01 December 2020

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